CHAPTER

9

SUPPORTING I/O DEVICES

In this chapter, you will learn:

- How to use standard resources on a computer system when installing add-on devices
- How to resolve resource conflicts
- How to install a new device on a computer
- About keyboards, pointing devices, and video subsystems

This chapter focuses on how to install and support I/O devices. You will first learn about procedures and guidelines that are common to most installations, including how to use serial, parallel, USB, IEEE 1394 ports, and expansion slots. You then turn your attention to the I/O devices common to every computer—a keyboard, pointing device, and monitor. This chapter builds the foundation for the next chapter, where multimedia devices are covered, including CD-ROM and DVD drives, sound cards, and digital cameras.

BASIC PRINCIPLES OF PERIPHERAL INSTALLATIONS

When you add new peripherals to a computer, the device needs a device driver or BIOS, system resources (which might include an IRQ, DMA channel, I/O addresses, and upper memory addresses), and applications software. Consider these fundamental principles:

- The peripheral is a hardware device that is controlled by software. You must install both the hardware and the software.
- The software might exist at different levels. For example, a device could require driver software that interfaces directly with the hardware device and an applications software package that interfaces with the driver. You must install all levels of software.
- Remember from Chapter 2 that more than one peripheral device might attempt to use the same computer resources. This conflict could disable one or both devices. Possible conflicts arise when more than one device attempts to use any of the following four system resources:
  - The same IRQ
  - The same DMA channel
  - The same I/O addresses
  - The same upper memory addresses (for 16-bit drivers)

A Review of System Resources

Before discussing principles of installation, let's review the concepts of the four system resources listed above that were first explained in Chapter 2. Recall that an IRQ is a line on a bus that serves as an interrupt request line and is assigned to a device. When the device needs attention, it signals the CPU through its assigned IRQ; it "raises" the IRQ line. The CPU then requests from the device an interrupt number (abbreviated INT). These numbers, used by hardware devices to request service from the CPU and by software to request that the CPU access a hardware device, are listed in Appendix G.

The CPU uses the INT to locate an entry in the interrupt vector table. This table, located in the lowest part of memory, stores the address of an interrupt handler, a program that handles the request. The program is either a device driver or BIOS and uses I/O addresses to communicate with the device. These I/O addresses are standard addresses always used by this program and device (for example, the keyboard always uses I/O addresses 60h–6Fh) or they are assigned to the program and device at startup.

Also remember that older device drivers and BIOS written in real mode require some upper memory addresses between 640K and 1024K. Some devices require a DMA channel to speed up transferring data across the bus. The DMA channel and upper memory addresses are also assigned at startup.

Sometimes devices connect to the system with a controller that manages the resources for it and other devices connected to the controller. One example of this type of setup is a PCI

device installed in a PCI expansion slot on the system board. The PCI device is managed by the PCI controller which is also on the system board. The system resources needed by the device are assigned to the PCI controller, which then manages these resources. Other types of subsystems that have a controller to manage system resources for the devices connected to the controller include SCSI, USB, and IEEE 1394. In all these cases, the controller can be embedded on the system board as part of the chip set or can be on a host adapter in an expansion slot. Whether on the system board or host adapter, the controller is assigned system resources, which are used to manage the devices connected to it. With SCSI, USB, and IEEE 1394, only one IRQ and I/O address assignment is needed for the controller, and the devices managed by the controller don't need individual resources assigned to them; they all share the same resources assigned to the controller.

Installation Overview

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You follow three basic steps to install an add-on device:

1. Install the device
2. Install the device driver
3. Install the applications software

The device can either be an internal (installed inside the computer case) or external device (installed outside the case). Devices installed inside the case are drives (hard drives, floppy drives, CD-ROM drives, DVD drives, Zip drives, etc.) or devices that are inserted in expansion slots on the system board (a modem card, video capture card, etc.). Drive installations are covered in other chapters. Using expansion slots to install a device is covered later in this chapter. You can install an external device using an existing port (serial, parallel, USB, or IEEE 1394 port), or a port provided by an interface card installed in an expansion slot.

An example of this last situation is a scanner, which is an external device. It uses an expansion card installed inside the case to interface with the system board. When you buy a scanner, the package might include an expansion card that provides a port for the scanner. You are buying (1) the scanner, (2) the expansion card that interfaces with the computer (for example, a SCSI host adapter to provide a SCSI port for the scanner), (3) the cable to connect the scanner to its expansion card, (4) the device driver on disk, (5) some applications software for using the scanner, and (6), very importantly, the documentation. Installing the hardware includes installing the expansion card in an expansion slot on the system board and then plugging in the scanner itself.

After physically installing the device, install the device driver. For DOS and Windows 3.x, installing the driver probably means executing a setup program from floppy disk or CD-ROM that copies the driver file to the hard drive and adds the DEVICE= command to CONFIG.SYS. For Windows 9x, start the setup program from the Start, Run command to install the device driver automatically. You also can open the Control Panel and choose the Add New Hardware option. A comprehensive example of these procedures is given at the end of this chapter.

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The driver and the scanner expansion card are specific for each brand and model of scanner; however, the applications software does not have as narrow an application. Any application package that uses a scanner should work with most scanners. In fact, you might have several applications that use the same hardware device.

The rest of this section discusses hardware devices, device drivers, and applications software in detail before turning to using standard ports on a computer system for installing devices.

Hardware Devices

Consider a hardware device such as a modem. You know that a modem provides a way to connect one computer to another, forming a network. There are many kinds of modems and networks. Some modems use normal telephone lines for communication, whereas others use dedicated circuits. Internal modems are expansion cards installed inside the computer case; they provide one or (usually) two telephone-line ports that connect a telephone line directly into the back of the computer. External modems are contained in their own case with their own power supply. The external modem is connected to the computer by a cable that plugs into the back of the computer case, usually to a serial port. The telephone line then plugs into the back of the modem. In either case, the modem converts the computer's bits to a form that can be communicated over telephone lines and other circuits.

Most often internal devices are less expensive than external devices, which have the additional expense of the power supply and case. Internal devices also offer the added advantage of not taking up desk space, and their cables and cords are neatly tucked away. An advantage of external devices is that they can be moved easily from one computer to another.

If you've ever shopped for a peripheral device, such as a modem or a sound card, you know what a large variety of features and prices today's market offers. Research pays. First, know your own computer system. Know which CPU, system bus, and local bus you have, and how much memory and what size hard drive your system has. Know which OS you are using and what version it is (for example, DOS 6.22 or Windows 98 Second Edition). Determine how much space is available on your hard drive, and how many expansion slots and what kinds of slots are free in your computer.

In addition to a basic knowledge of your system, you might need some technical information. For example, most computers have a power supply that well exceeds the requirements of the standard system, making it possible to add internal devices without exceeding the total available wattage. However, if your computer is old (for computers, that's over five years), and you're adding more than one internal device, the power supply could limit your choices. If you install more internal devices than the power supply can handle, you might need to upgrade the power supply.

Unless you are using Plug and Play-compliant devices and a Plug and Play OS, know what IRQs, I/O addresses, DMA channels, and upper memory addresses your present devices use. Recall that a notebook dedicated to your PC, as discussed in Chapter 8, should have records of each device and the present settings of the device.

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TIP: To find out what IRQs, I/O addresses, DMA channels, and upper memory addresses your devices are using, use MSD for DOS and Device Manager for Windows 9x.

Generally, if you buy the device and other accompanying hardware (such as the interface board and cables) from the same source, they are more likely to be compatible.

Embedded BIOS on Devices

A peripheral device can require several levels of software to make it work. Recall from Chapter 1 that the most fundamental software needed is stored on ROM chips inside the device or on the interface board, and is called BIOS, or firmware. Some devices also contain some memory or RAM to temporarily store data moving through the device. Sometimes you must interface with the BIOS to set a parameter, such as the IRQ number. If the device and your system are Plug and Play, you do not need to change the resource parameters of the device. If you are not using Plug and Play, you can set a parameter of the BIOS by changing a DIP switch or jumper setting. However, for some sophisticated devices, you can interface with the BIOS using programs provided by the manufacturer, which present a chip setup screen similar to the system board CMOS setup screen. The documentation for the device should tell you what parameters you can change and how to communicate those changes to the BIOS. SCSI devices quite often use this method for setup.

The DIP switches and jumpers are normally set by the manufacturer in the most commonly used default settings. Don't change a DIP switch or jumper on a device without (1) writing down the original settings so you can backtrack, and (2) carefully reading the documentation.

Why change a BIOS parameter? The most common reason is to prevent a conflict in the assignment of computer resources. If you buy a second modem to install on your computer, and both modems are using the same IRQ by default, you might be able to instruct the new modem to use an alternate IRQ by changing DIP switches or jumpers on the modem. Making this change tells BIOS on the modem to use the alternate IRQ.

For example, Figure 9-1 shows a modem that has a bank of DIP switches on the back of the card and a bank of jumpers on the card itself (see Figure 9-2). By using combinations of these DIP switches and jumpers, you can configure this modem either to be Plug and Play compliant or to use a specific set of IRQ and I/O addresses.

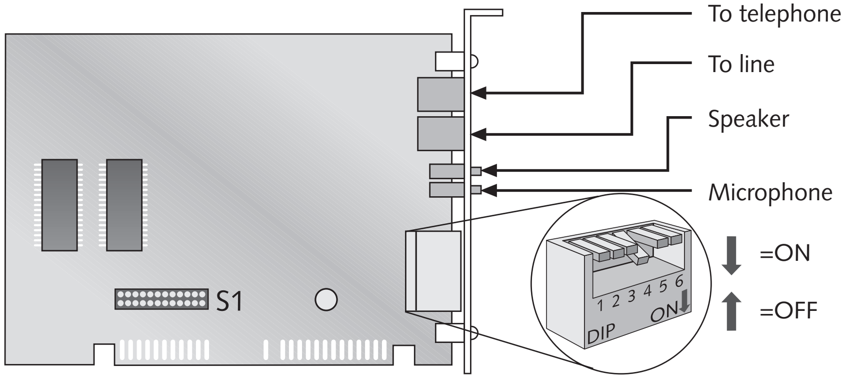

Figure 9-1 Diagram of a modem card

In addition to BIOS on the device, system BIOS might also be involved. A good example of this is a hard drive. BIOS on the hard drive housing manages direct access to the drive, but system BIOS on the system board can manage communication between the hard drive BIOS and the OS.

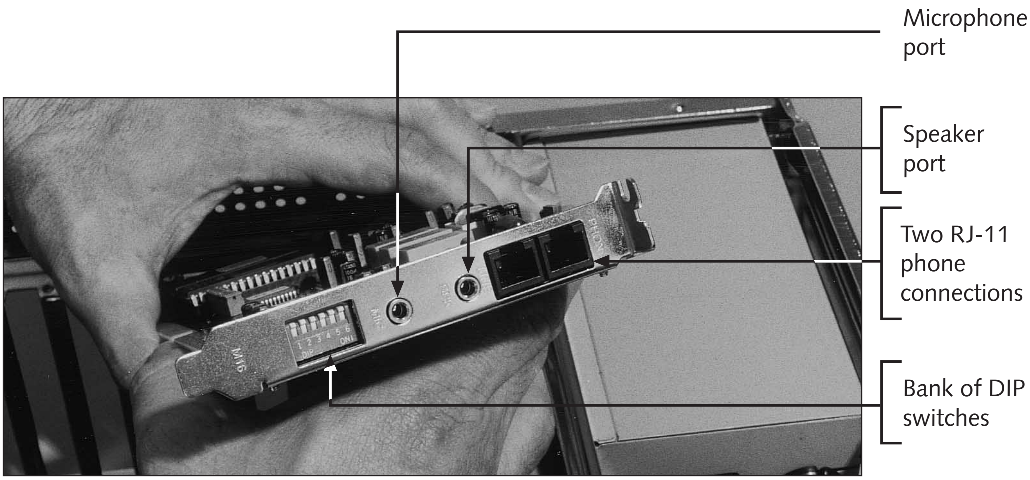

Figure 9-2 Ports and DIP switches on the back of an internal modem

Device Drivers

The second level of software needed by a peripheral device is a device driver. As explained in Chapter 2, there are two kinds of device drivers: 16-bit real-mode drivers and 32-bit protected-mode drivers. Windows 9x contains 32-bit drivers for hundreds of hardware devices. Windows automatically loads these drivers into extended memory (memory above 1024K) at startup or when the device first needs them. However, not all devices are supported by Windows drivers, so you may need to use an older 16-bit real-mode device driver. These 16-bit drivers are loaded by entries in the CONFIG.SYS or AUTOEXEC.BAT file and use upper memory addresses.

Device Drivers under DOS

A common 16-bit DOS device driver is the mouse driver. For example, the device driver MOUSE.SYS is loaded in the CONFIG.SYS file with this command:

```
DEVICE=C:\UTIL\MOUSE.SYS
```

The DEVICE= command in CONFIG.SYS tells DOS that the program file named MOUSE.SYS stored in the \UTIL directory on drive C is a TSR needed to drive a device. Sometimes the device driver needs some parameters or switches listed at the end of the command line. For example, a device driver can direct a serial port mouse to use COM 2 instead of the default, COM 1, by adding a parameter to the end of the command line:

```
DEVICE=C:\UTIL\MOUSE.SYS /C2
```

See your documentation to find out what parameters you can use on the command line for a device driver.

Another type of mouse device driver is loaded from the AUTOEXEC.BAT file and the command line might look like this:

```
C:\UTIL\MOUSE.COM /C2
```

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Device Drivers Under Windows 9x

Windows 9x provides 32-bit device drivers for a mouse, so you normally do not need to use a 16-bit driver in CONFIG.SYS as shown above for DOS. However, if you wanted to boot to DOS from a floppy disk and use a mouse, put the mouse device driver entry in the CONFIG.SYS file on your disk together with the driver file MOUSE.SYS.

For Windows 9x, the device driver is installed at the time the hardware device is installed, information about the driver installation is kept in the Windows 9x Registry, and then the driver is automatically executed each time Windows 9x starts or the device is used. Windows 32-bit drivers can be loaded into memory when the device is accessed and then unloaded to conserve memory when the device is disconnected or turned off.

Most often the device driver comes as part of the hardware package. For example, when you buy a video or sound card, a disk is enclosed that contains the driver. You want to use the latest 32-bit driver available. Windows 98 has added many drivers to the list of those supported by Windows 95. Select the latest driver available for that device, either provided by Windows or by the device manufacturer. Occasionally, a manufacturer releases a new, improved device driver for a device. You can most likely download these new drivers from the manufacturer's web site.

You can view and change current device drivers from the Control Panel. For example, in Windows 98, to view the current video driver, click **Start**, **Settings**, **Control Panel**, and double-click **Display**. Click the **Settings** tab to view the currently installed display driver, as seen in Figure 9-3.

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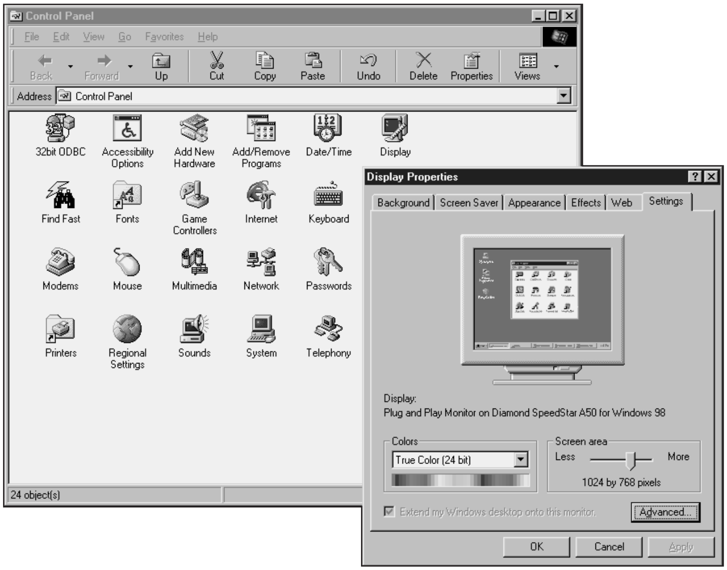

Figure 9-3 Use the Settings tab of Display Properties to view the currently installed display driver

To change the driver, click **Advanced**. Click the **Adapter** tab, and then click the **Change** button. You see the Windows 98 Update Device Driver Wizard. Click **Next** to see the dialog box in Figure 9-4, which includes options to let Windows 98 search for a new driver from its list of supported drivers or to let you perform the search manually. If you have a new driver that is not supported by Windows 98 (such as one that you just downloaded from the Internet), choose to perform the search manually. Select **Display a list of all the drivers in a specific location, so you can select the driver you want** and click **Next**. You see the dialog box in Figure 9-5, showing the currently selected driver. Click **Have Disk** to provide the new driver from a floppy disk, a CD-ROM, or a downloaded folder on your hard drive.

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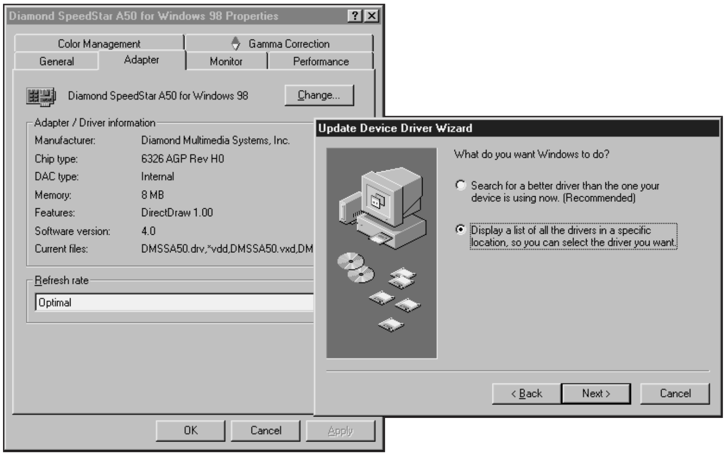

Figure 9-4 The Windows 98 Update Device Driver Wizard enables you to install a new device driver for a previously installed device

Figure 9-5 If you have a new driver for a device that Windows 98 does not offer, click Have Disk

TIP

When you upgrade from DOS with Windows 3.x to either Windows 9x or Windows NT, use the latest 32-bit drivers. If Windows 9x or Windows NT does not support a hardware device installed on your system, the solution may be to use the Internet to locate a new 32-bit driver for your device. One of the projects at the end of this chapter shows you how.

Sixteen-bit drivers under Windows 9x can cause slow performance, so use 32-bit drivers when possible. To identify whether Windows 9x is using a 16-bit driver, click **Start**, **Settings**, **Control Panel**, double-click **System** and select **Device Manager**. Look for an

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exclamation point beside the device, which indicates that the driver has a problem. Table 9-1 summarizes basic information about device drivers under Windows 9x.

Table 9-1 Two types of device drivers and how to use them under Windows 9x

Characteristic	16-bit Device Drivers	32-bit Device Drivers
Operating mode	Real mode	Protected mode
Use of memory	May use upper memory addresses	Stored in extended memory
How loaded	Loaded by a command line in CONFIG.SYS or AUTOEXEC.BAT	Automatically loaded by Windows 9x at startup or when the device is used
How changed	Edit the CONFIG.SYS or AUTOEXEC.BAT file	From Device Manager, select the device and use Properties, Driver tab
How to identify the type	In Device Manager, look for an exclamation point beside the device name	Look for no exclamation point beside the device name in Device Manager. Also, typically "32" is included in the driver filename.
When to use this type	Use a 16-bit driver under Windows only when a 32-bit driver is not available. When operating under DOS, 16-bit drivers are required.	When you can, always use 32-bit drivers because they are faster

Applications Software

The next level of software is the applications software that uses the device. Most devices include applications software, such as voice messaging software to use with a modem or software to scan and manipulate images that comes with a scanner. You can use applications software other than the package that comes with the device, and, if you have other software, it isn't necessary to install the bundled software.

When you install older 16-bit applications software, you might need to provide some information about the hardware devices it uses. For example, for the 16-bit version of ProComm, a communications software package that can communicate with a modem, if an internal modem is configured to use COM2 by a DIP switch on the modem, ProComm must also be told to look for the modem on COM2. If the modem is communicating on COM2, and ProComm is communicating on COM1, ProComm will not find the modem. On the setup screen in ProComm, you can choose COM2 as the communications port.

Using Ports and Expansion Slots for Add-on Devices

Devices can be plugged directly into a serial, parallel, USB, or IEEE 1394 port, or they can use an expansion card plugged into an expansion slot. Some devices use a peripheral bus, called a SCSI bus, that interfaces with the local bus through a SCSI expansion card called the host adapter. The text below addresses the specific details of these kinds of installations.

All computers come with one or two serial ports, one parallel port, and, on newer computers, a USB port and IEEE 1394 port. Newer system boards have serial, parallel, and USB ports and perhaps a IEEE 1394 port directly on the board (called on-board ports), but, on older system boards, an **I/O controller card** in an expansion slot supplied the serial and parallel ports.

Using Serial Ports

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Serial ports transmit data in single file, or serially. You can identify these ports on the back of a PC case by (1) counting the pins and (2) determining if the port is male or female. Figure 9-6 shows serial ports, a parallel port, and a game port, for comparison. On the top is one 25-pin female parallel port and one 9-pin male serial port. On the bottom is one 25-pin male serial port and a 15-pin game port. Serial ports are sometimes called DB-9 and DB-25 connectors. DB stands for data bus and refers to the number of pins on the connector. Serial ports are almost always male ports, and parallel ports are almost always female ports.

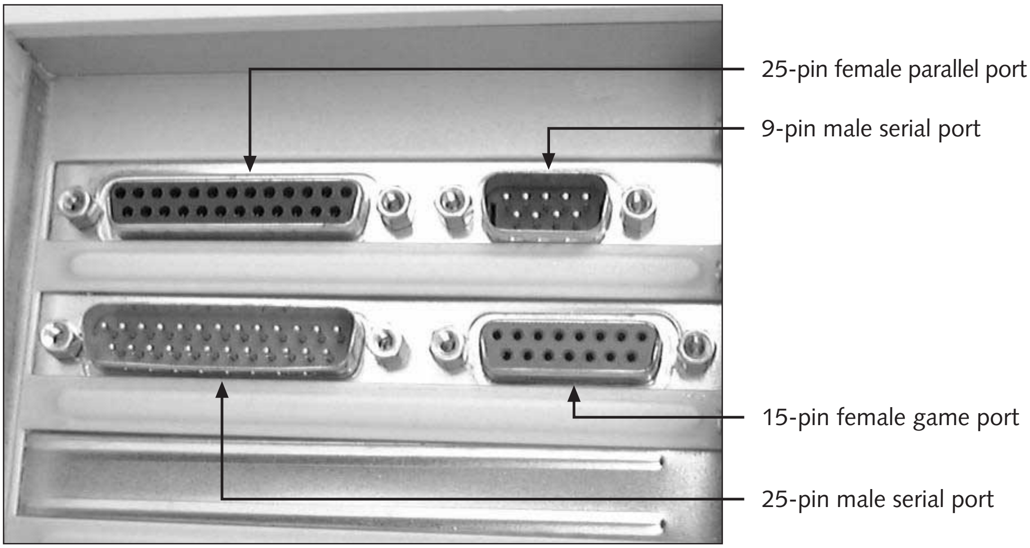

Figure 9-6 Serial, parallel, and game ports

To simplify the allocation of system resources, two configurations for these serial ports were designated as COM1 and COM2, and then later two more configurations were designated as COM3 and COM4. These COM assignments each represent a designated IRQ and I/O address, as seen in Table 9-2. Think of the serial ports as physical, and of COM1 and COM2 as logical assignments to these physical ports, much as a phone number is a logical assignment to a physical telephone (Figure 9-7). In reality, COM1 is just a convenient way of saying IRQ 4 and I/O address 03F8h. Also notice in Table 9-2 that the two parallel port configurations are named LPT1 and LPT2 and each is assigned an IRQ and I/O address. DOS, Windows, and most applications that use serial devices know about and comply with these assignments. For example, you can tell your communications software to use COM1

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to communicate with a modem, and it then knows that the modem is using IRQ 4 to signal the CPU and "listening" for instructions by way of I/O address 03F8h.

Table 9-2 Default port assignments on many computers

Port	IRQ	I/O Address (in Hex)	Type
COM1	IRQ 4	03F8 – 3FF	Serial
COM2	IRQ 3	02F8 – 2FF	Serial
COM3	IRQ 4	03E8 – 3EF	Serial
COM4	IRQ 3	02E8 – 2EF	Serial
LPT1	IRQ 7	0378 – 37F	Parallel
LPT2	IRQ 5	0278 – 27F	Parallel

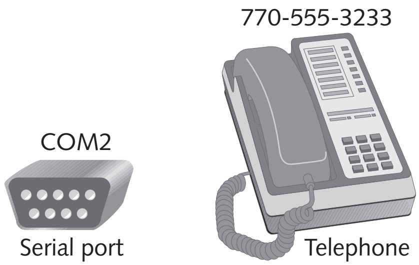

Figure 9-7 A serial port is assigned COM2 much as a telephone is assigned a phone number

Serial ports were originally intended for input and output devices, and parallel ports were intended for printers. Serial ports can be configured for COM1, COM2, COM3, or COM4. Parallel ports can be configured as LPT1, LPT2, or LPT3.

To configure a serial port with a COM assignment, if it is on an I/O card, you would most likely set jumper switches on the card. If they are connected directly to the system board, most often the assignments are made in CMOS setup. Sometimes the setup screen shows the COM assignments, and sometimes you see the actual IRQ and I/O address assignments, as seen in Figure 9-8.

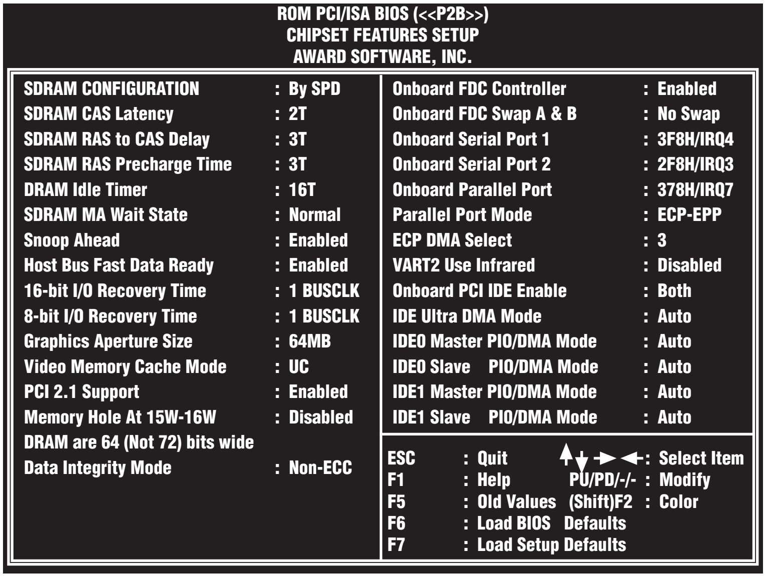

Figure 9-8 CMOS setup screen for chipset features

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A serial port conforms to the standard interface called RS-232c (stands for Reference Standard 232 revision c) and is sometimes called the RS-232 port. This interface standard originally called for 25 pins, but since microcomputers only use 9 of those pins, a modified, 9-pin port was often installed by the manufacturer. Today some computers have a 9-pin serial port, and some have a 25-pin serial port, or both. Both ports work the same way. The 25-pin port uses only 9 pins; the other pins are unused. Serial 25-pin ports are often found on modems. You can buy adapters that convert 9-pin ports to 25-pin ports, and vice versa, to accommodate a cable you already have.

One of the 9 pins on a serial port transmits data in a sequence of bits, and a second pin receives data sequentially. The other 7 pins are used to establish the communications protocol. A protocol is a set of agreed-upon rules for communication that is established before data is actually passed from one device to another. Table 9-3 describes the functions of the pins of a serial port connection to a modem connected to another remote modem and computer. External modems sometimes use lights on the front panel to indicate the state of these pins. The labels on these modem lights are listed in the last column.

The table is included not so much to explain the use of each pin, as to show that more than just data is included in a serial communication session. Also, when the system is using serial ports, one of the devices is called the DTE (Data Terminal Equipment), and the other device is called the DCE (Data Communications Equipment). For example, a modem is called the DCE and the computer on which it is installed is called the DTE.

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Table 9-3 9-pin and 25-pin serial port specifications

Pin Number for 9-Pin	Pin Number for 25-pin	Pin Use	Description	LED Light
1	8	Carrier detect	Connection with remote is made	CD or DCD
2	3	Receive data	Receiving data	RD or TXD
3	2	Transmit data	Sending data	SD or TXD
4	20	Data terminal ready	Modem hears its computer	TR or DTR
5	7	Signal ground	Not used with PCs	
6	6	Data set ready	Modem is able to talk	MR or DSR
7	4	Request to send	Computer wants to talk	RTS
8	5	Clear to send	Modem is ready to talk	CTS
9	22	Ring indicator	Someone is calling	RI

Null Modem Connection

When two DTE devices, such as two computers, are connected, software can transmit data between the two DTE devices over a special cable called a **null modem cable**, or a **modem eliminator**, without the need for modems. The cable is not a standard serial cable, but has several wires cross-connected in order to simulate modem communication. For example, based on the 9-pin specifications in Table 9-3, a 9-pin null modem cable would connect pin 2 on one end of the cable to pin 3 on the other end of the cable with a single wire, so that the sending data on one end is the receiving data on the other end. Similarly, pin 3 would be connected to pin 2 on the other end of the cable, so that the received data on one end is the sent data on the other end. Crossing pins 2 and 3 allows data to be sent from one computer and received by the other. Standard modem software can often be used to transmit data, but because there are no actual modems in the connection, very fast, accurate transfer is possible.

Table 9-4 describes the pins connected and crossed for a 25-pin null modem cable. Figure 9-9 shows the same information as a picture.

Table 9-4 Pin connections for a 25-pin null modem cable

Pin on one end is	Connected to the pin on the other end	So that:
2	3	Data sent by one computer is received by the other
3	2	Data received by one computer is sent by the other
6	20	One end says to the other end, “I'm able to talk”
20	6	One end hears the other end say, “I'm able to talk”
4	5	One end says to the other, “I'm ready to talk”
5	4	One end hears the other say, “I'm ready to talk”
7	7	Both ends are grounded

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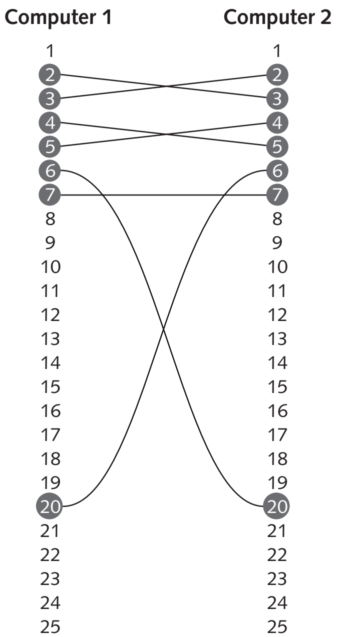

Figure 9-9 Wire connections on a 25-pin null modem cable used to transmit data

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Infrared Transceivers

An infrared transceiver that supports infrared devices, such as wireless keyboards and printers, can connect directly to a serial port. If the transceiver is Plug and Play, connect the device and turn on the PC. Windows automatically detects and installs the infrared driver using the Add New Hardware Wizard. For legacy transceivers, install the transceiver using the Add New Hardware icon in Control Panel. The transceiver uses the resources of the serial port for communication and also creates a virtual infrared serial port and virtual infrared parallel port for infrared devices. During the installation, you are told what these virtual ports are and given the opportunity to change them. For example, if you physically connect the transceiver to COM2, the virtual ports will be COM4 for infrared serial devices and LPT3 for an infrared printer. The IRQ and I/O addresses for the infrared system are those assigned to COM2. To activiate the transceiver, double click the **Infrared icon** in Control Panel. If the icon is not displayed, press F5 to refresh Control Panel.

In addition, some system boards provide a 5-pin connection for its own proprietary IRDA-compliant infrared transceiver. In this case, the transceiver mounts on the outside of the case and a wire goes through a small hole in the case to connect to the 5-pin connection. The system board manual instructs you to use CMOS setup to enable "UART2 Use Infrared." When you do that, COM2 serial port is disabled because the transceiver is using the resources or that port. The transceiver drivers are then installed and used the same way as described above.

The UART Chip

Serial ports are controlled by a chip called the **UART chip (universal asynchronous receiver/transmitter chip)**. This chip controls all 9 pins of a serial port, establishes the communications protocol, and converts parallel data bits coming from the system bus into serial bits for transmission. It also converts incoming serial data bits it receives into the parallel form needed by the system bus. The first UART chip was the 8250, and the next version was called the 16450 chip. The 16550 version of the UART chip contains a FIFO buffer (first in, first out buffer) that solves the problem of lost data that sometimes occurs with the 16450 UART. Also, look for improved versions of the chip labeled 16550A, 16550AF, and 16550AFN, each improving on the one before it. Some computers don't actually have the physical chip on the board, but the UART logic is contained in another chip. However, in all cases, utility software can tell you what is present.

Many inexpensive I/O cards and some system boards that have on-board serial ports still use the 16450 UART, which can cause lost data and slow transmission. The 16550 UART requires a driver that makes use of the FIFO buffer. Windows 9x uses this faster driver, but if you are using DOS or Windows 3.x, check the driver being used and upgrade if necessary.

The UART 16550 driver is built into Windows 9x. To verify that you are using the driver, click **Start**, point to **Settings**, and then click **Control Panel**. Double-click **System** and choose the **Device Manager** tab. Click the **+** sign beside **Ports** to reveal the list of ports. Click a communications port, such as **COM1**, and then click **Properties**. Click the **Port Settings** tab. You see the Properties dialog box in Figure 9-10. Note that the drop-down list shows the bits per second, or baud rate, of the port, which is currently set at 115,200 bps. Don't expect the port rate to exceed this value unless you are using the 16550A UART chip with buffering. Click **Advanced** to see the Advanced Port Settings illustrated in Figure 9-11. Note that **Use FIFO buffers** is checked. The standard FIFO buffer for the 16550 is 16 bytes long, which is indicated by the high range for the buffer size. Newer UART chips exceed this buffer size, so you should expect an improved version of the Windows 98 serial port driver to follow shortly. In the meantime, you can use third-party UART drivers such as TurboCom/95 Communications Drivers that support port speeds up to 921,600 bps. See *www.turbocom.com*.

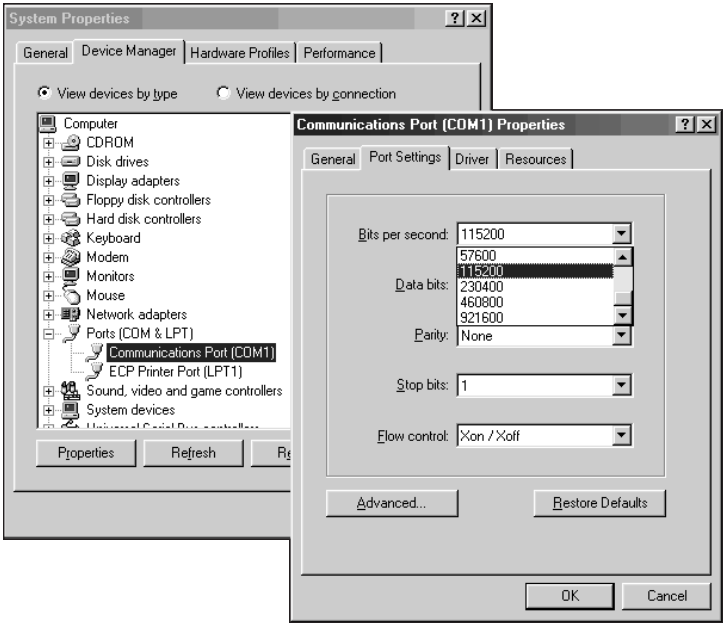


Figure 9-10 Properties of the COM1 serial port in Windows 9x

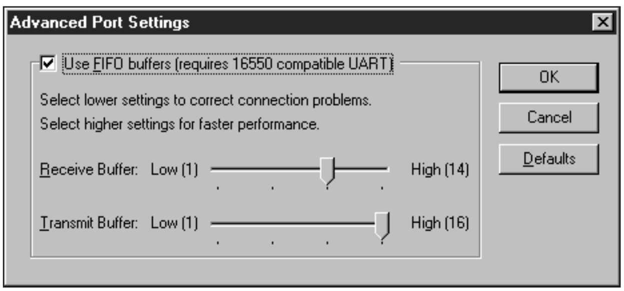


Figure 9-11 Windows 9x Advanced Port Settings for the COM1 serial port, indicating FIFO option

One example of a newer UART chip by Texas Instruments, the TL 16C754, has a 64-byte buffer. Another example by Lava Computer Manufacturing, Inc., called the LavaPort 16650, increases speed by (1) using a faster clock speed, (2) increasing the buffer size (64 bytes), and (3) improving flow control. Lava puts the chip on a serial port accelerator card capable of a port speed baud rate of 460,800 bps. The web sites of these two manufacturers are *www.lavalink.com* and *www.ti.com*.

Also, some UART chips are Plug and Play compliant. These UART chips provide an interface with Plug and Play ROM so that they are automatically configured at startup. Texas Instruments now offers Plug and Play-compliant UART chips.

If you are losing data when using an external modem, first determine the kind of UART chip the serial port is using. You might need to upgrade to the 16550 or 16650 chip. Internal modems have their own UART chip on the card, or other chips that simulate the UART interface. If the UART logic is integrated into other chips, they most likely cannot be changed.

For older PCs using DOS and Windows 3.x, determine what kind of UART chip you have by using MSD.EXE. From the main menu of MSD, choose the **COM port** option. MSD displays information about each serial or COM port, including the UART chip used. However, if you execute MSD while Windows is running, the information can be deceiving. For example, Figure 9-12 shows the results of the MSD report taken while Windows was not running. Figure 9-13 is an MSD report from the same computer while Windows was running. Compare the results. With Windows running, the COM1 serial port shows the UART chip as the older 8250 chip. In fact, the UART chip on this general-purpose I/O card is the 16550AF chip, which, when Windows is running, is correctly reported for COM2 because COM2 is in use; it is incorrectly reported for COM1 because COM1 is not in use. On this computer, a serial port mouse is using COM2. Because COM2 is in use, Windows correctly recognizes the UART chip, and MSD can pick up the correct information. The information from MSD without Windows is correct.

```
Microsoft Diagnostics version 2.00 7/05/97 9:35am Page 1
========================================================

------------------- COM Ports ------------------
                      COM1:    COM2:  COM3:  COM4:
                      -----    -----  -----  -----
 Port Address         03F8H    02F8H   N/A    N/A
 Baud Rate             1200     2400
 Parity                None     None
 Data Bits                7        8
 Stop Bits                1        1
 Carrier Detect (CD)     No       No
 Ring Indicator (RI)     No       No
 Data Set Ready (DSR)    No       No
 Clear To Send (CTS)     No       No
 UART Chip Used     16550AF  16550AF
```

Figure 9-12 MSD COM port report from DOS prompt without Windows

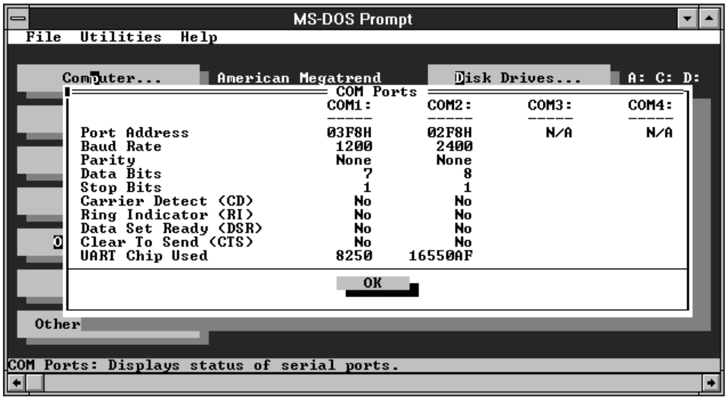


Figure 9-13 MSD COM port report from DOS prompt with Windows 3.x running

Another interesting fact about this particular computer is that the documentation that came with the I/O card stated that the UART chip is a 16450 UART. Here's a case where the manufacturer updated the product but not the documentation that came with the product.

Resources Used by Serial Ports

Table 9-2 listed the I/O addresses for standard serial and parallel ports. You can view I/O addresses using the DOS or Windows MSD command or from Device Manager of Windows 9x.

In summary, serial ports are used for various input/output data transfers, including data transferred over modems, to mice, to printers, and to other computers. Serial ports follow the RS-232c industry standard for communication. Each port is assigned a unique IRQ and a unique I/O address. The UART chip controlling the port is partially responsible for the speed of the port.

Using Parallel Ports

A+ CORE 2.1, 4.3

Parallel ports, commonly used by printers, transmit data in parallel, 8 bits at a time. If the data is transmitted in parallel over a very long cable, the integrity of the data is sometimes lost because bits may separate from the byte they belong to. Most parallel cables are only 6 feet long, though no established standards sets maximum cable length. However, avoid using a parallel cable longer than 15 feet to ensure data integrity. Hewlett-Packard recommends the cables be no longer than 10 feet.

Parallel ports were originally intended to be used only for printers. However, some parallel ports are now used for input devices. These bi-directional parallel ports are often used for fast transmission of data over short distances. One common use is to download and upload data from a PC to a laptop. Some external CD-ROM drives use a bi-directional parallel port to transmit and receive data. If you use an existing parallel port to install a peripheral device, installation is very simple. Just plug the device into the port and load the software. To accommodate a second parallel port, configure the port as LPT2. An example of this is described in the next section.

A+ CORE 1.4

The uses of the pin connections for a 25-pin parallel port are listed in Table 9-5.

Table 9-5 25-pin parallel port pin connections

Pin	Input or Output from PC	Description
1	Output	Strobe
2	Output	Data bit 0
3	Output	Data bit 1
4	Output	Data bit 2
5	Output	Data bit 3
6	Output	Data bit 4
7	Output	Data bit 5
8	Output	Data bit 6
9	Output	Data bit 7
10	Input	Acknowledge
11	Input	Busy
12	Input	Out of paper
13	Input	Select
14	Output	Auto feed
15	Input	Printer error
16	Output	Initialize paper
17	Output	Select input
18	Input	Ground for bit 0
19	Input	Ground for bit 1
20	Input	Ground for bit 2
21	Input	Ground for bit 3
22	Input	Ground for bit 4
23	Input	Ground for bit 5
24	Input	Ground for bit 6
25	Input	Ground for bit 7

A+ CORE 4.4, 2.1

Types of Parallel Ports

Parallel ports fall into three categories: standard, **enhanced parallel port** (**EPP**), and **extended capabilities port** (**ECP**). The standard parallel port (SPP) is sometimes called a normal parallel port or a Centronics port, named after the 36-pin Centronics connection used by printers (see Figure 9-14). A standard port only allows data to flow in one direction and is the slowest of the three types of parallel ports. EPP and ECP are both bi-directional. ECP was designed to increase speed over EPP by using a DMA channel; therefore, when using ECP mode you are using a DMA channel. Over the years both hardware and software manufacturers have implemented several parallel port designs, all attempting to increase speed and performance. To help establish industry standards, a committee was formed in the early

A+ CORE 4.4, 1.4, 2.1

90s supported by the Institute of Electrical and Electronics Engineers (IEEE), which created the **IEEE 1284** standards for parallel ports. These standards require backward compatibility with previous parallel port technology. Both EPP and ECP are covered under the IEEE 1284 specifications.

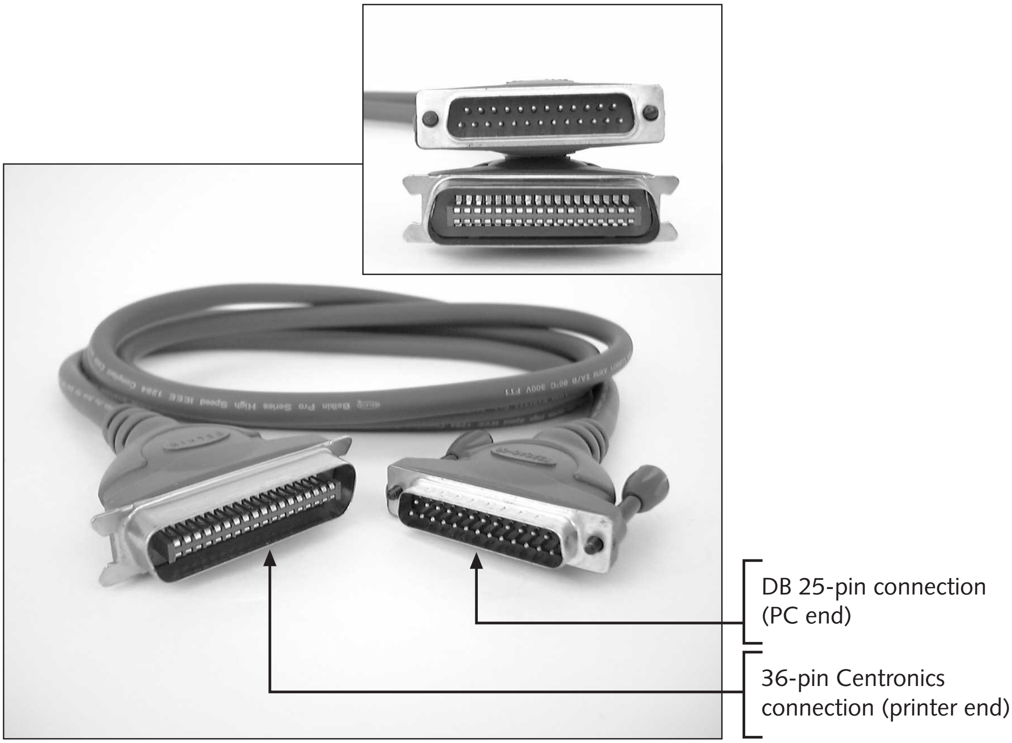


Figure 9-14 A parallel cable has a DB-25 connection at the PC end of the cable and a 36-pin Centronics connection at the printer end of the cable

Configuring Parallel Ports

When configuring a parallel port, if the port is on an I/O card, then look to the documentation for the card to know how to assign system resources to the port. If the parallel port is coming directly off the system board, then look to CMOS setup to configure the port (see Figure 9-8). Setup can have up to three different settings for parallel ports. For the BIOS in this figure, choices for parallel port mode are Normal, EPP, ECP, and EPP 2 ECP. If you select ECP or EPP + ECP, you must also make an ECP DMA selection. Choices are DMA Channel 1 or 3. If you are having problems with resource conflicts, try disabling ECP mode for the parallel port. EPP mode gives good results and does not tie up a DMA channel.

Examining a General-Purpose I/O Card

Because you occasionally see the older technology when servicing a PC, this section briefly discusses a general-purpose I/O card, shown in Figure 9-15. The card is designed to be used

with a system board that does not have serial or parallel ports, or floppy drive or hard drive connections, although it can be used to add extra ports to a system board that already has some of these. The card has one floppy drive connection and an IDE adapter supplying one IDE hard drive connector (labeled the IDE HDD connector), which can accommodate two hard drives by means of a two-connection cable. Directly on the back of the card is one 9-pin male serial port and one 25-pin female bi-directional parallel port. Short cables connect to an adjacent bracket that contains a 15-pin female game port and a 25-pin male serial port (see Figure 9-16). The card also has an internal game port connector.

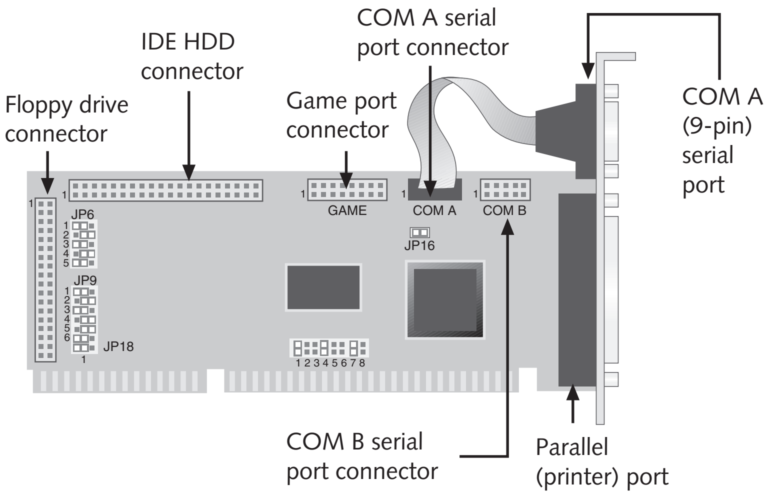


Figure 9-15 General-purpose I/O card

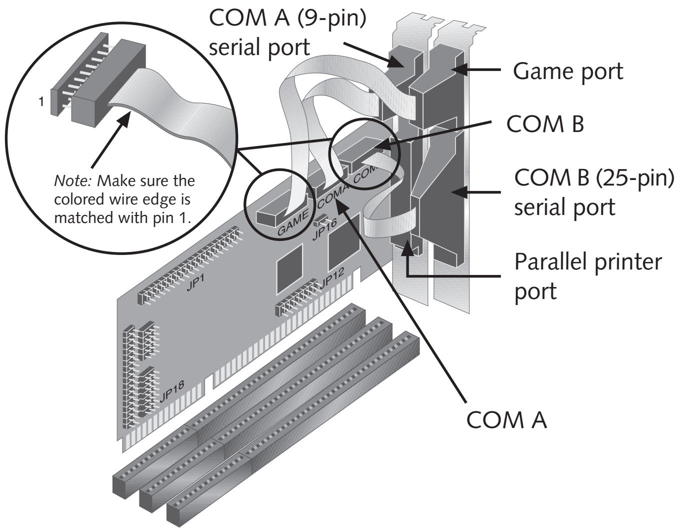


Figure 9-16 Installing a general-purpose I/O card

This card is not Plug and Play compliant. The card has four banks of jumpers which allow you to configure the card's ports. To know which jumper controls a particular setting, read the documentation for the card.

The card allows no choices for hard drive or floppy drive I/O port addresses because the values are established standards that never change. For serial ports, when you select COM1, COM2, COM3, or COM4 for the port, you are also selecting the I/O port address. You can, however, select the IRQ separately from the COM assignment.

To configure the parallel port, you choose the I/O port addresses rather than LPT1, LPT2, or LPT3. The parallel port is assigned by the BIOS according to the I/O port address. The parallel port with the highest I/O address (3BCh) is LPT1. The next automatically becomes LPT2, and the port with the lowest I/O address is LPT3. The default I/O address for this card is 278h (sometimes the default is 378h), which is LPT1 if the system has no other parallel ports. If the system board has another I/O card or a parallel port, be certain that its address is not 278h. Depending on the setting of the I/O address of the other parallel port, the system may configure this parallel port set to 278h as LPT1 or LPT2. Figure 9-16 shows the card inserted in an expansion slot with the cables connected to all four external ports.

Using USB Ports

A+ CORE 5.1, 4.3, 1.7

Using USB ports is easier than using parallel or serial ports because the USB controller together with support from the OS manages the USB port resources for you. Newer system boards have one or two USB ports. For older system boards, you can purchase a PCI expansion card to provide a USB port.

Recall from Chapter 2 that all the USB ports and USB devices connected to them use a single IRQ, I/O address, and DMA channel, which is similar to the way a SCSI bus works. See Figure 9-17. The OS must support the USB host controller. Windows 95 OSR 2.1 was the first Microsoft OS to support USB, although Windows 98 offers much improved USB support. Windows NT and Windows 95a do not support USB. The current version of the USB standard is version 1.1 which supports speeds up to 12 Mbps. An improved standard, USB 2.0, is expected soon and will support speeds up to 480 Mbps. USB transfers data in packets and can partly improve the speeds of serial and parallel ports because it uses higher quality cabling. A USB cable has four wires; two are used for data, one is ground, and one provides up to five volts of power to the device.

You don't need to manually assign system resources to a USB device, because the OS and the USB host controller automatically do that at startup. To install a USB device, you need:

- A system board or expansion card that provides a USB port and USB firmware
- An OS that supports USB
- A USB device
- A USB device driver

Windows 98 provides many USB device drivers. If you are installing a USB device, don't use a device driver from the manufacturer that claims to work only for Windows 95. Windows 98

A+CORE 5.1, 1.7, 1.3

made several improvements in USB support that you should take advantage of. Sometimes setup on a system board lets you disable USB support.

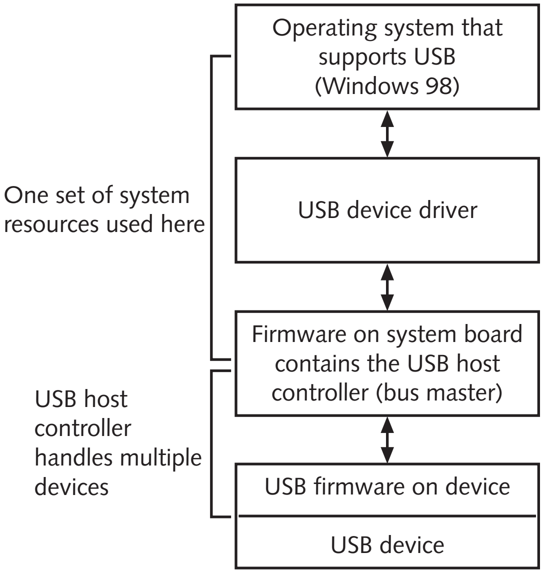


Figure 9-17 Only one IRQ, I/O address, and DMA channel are needed for a USB host controller to manage multiple devices

Follow these steps to install a USB device:

1. Using Device Manager, verify that the USB host controller driver is installed under Windows 9x. See Figure 9-18. Note in the figure the symbol for USB. If the controller is not installed, install it from the Control Panel by double-clicking the **Add New Hardware** icon. If you have a problem installing the controller, verify that support for USB is enabled in setup.
2. Plug in the USB device and install its device driver. For example, for a scanner, insert the CD that came with the scanner in the CD-ROM drive and enter **D:\Setup.exe** in the Run dialog box, where D is the name of the CD drive. After the drivers are installed, you should see the device listed in Device Manager. Verify that Windows sees the device with no conflicts and without errors.
3. Install the applications software to use the device. Most scanners come with some scaled-down version of software to scan and edit images. After you have installed the software, use it to scan an image.

A+ CORE 5.1, 1.7

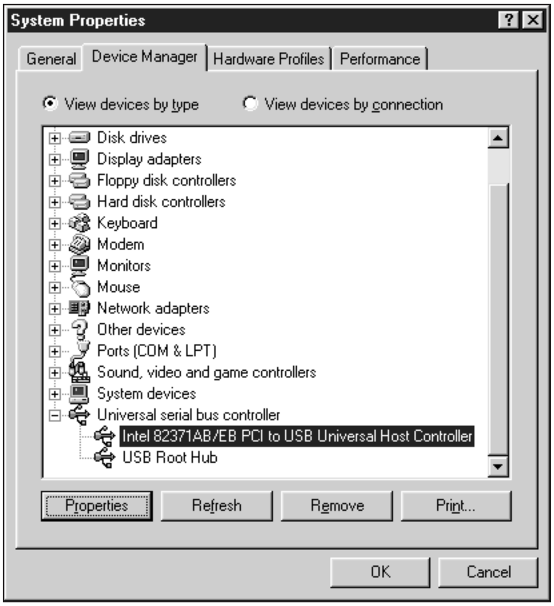


Figure 9-18 Using Device Manager, verify that the USB host controller is installed

Using IEEE 1394 Ports

A+ CORE 1.4, 1.7

IEEE 1394 ports are sometimes found on newer high-end system boards and are expected to become standard ports on all new system boards—as commonplace as USB ports are now. These ports have two types of connectors: a 4-pin port that does not provide voltage to a device and a 6-pin port that does. See Figure 9-19. The two extra pins in the 6-pin port are used for voltage and ground. The cable for a 6-pin port is fatter than the 4-pin cable.

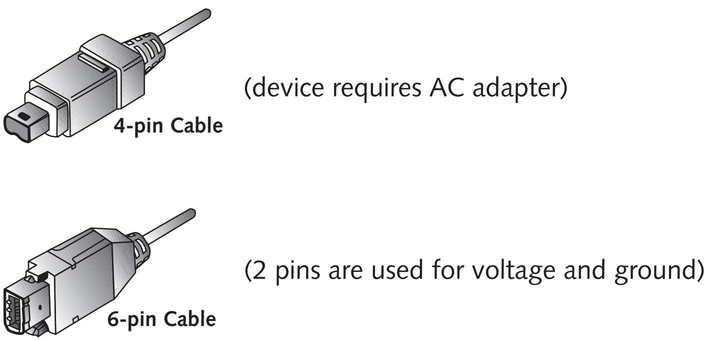


Figure 9-19 Two types of IEEE 1394 cable connectors; the 6-pin cable provides voltage to the device from the PC

A+CORE 1.7

The four wires used for data in a 1394 cable are two pairs of shielded twisted pair cable wrapped in a common cord. Shielding refers to how wires are enclosed in a protective covering to reduce interference, and twisted pair refers to the fact that two wires are twisted to reduce interference. Some network cabling is also shielded and uses twisted pair wires. In fact, IEEE 1394 uses a design similar to Ethernet, the most popular network design. Just as with Ethernet, data is broken into small packets before it is sent over 1394 cable. Each device on the IEEE 1394 network can communicate with any other device on the network without involving the computer's CPU.

IEEE 1394 uses **isochronous data transfer** meaning that data is transferred continuously without breaks. This works well when transferring real-time data such as that received by television transmission. Because of the real-time data transfer and the fact that data can be transferred from one device to another without involving the CPU, IEEE 1394 is an ideal medium for data transfers between consumer electronics products such as camcorders, VCRs, TVs and digital cameras.

Figure 9-20 shows an example of how this might work. A person can record a home movie using a digital camcorder and download the data through a digital VCR to a 1394-compliant hard drive. The 1394-compliant digital VCR can connect to and send data to the hard drive without involving the PC. The PC can later read the data off the hard drive and use it as input to video editing applications software. A user can edit the data and design a professional video presentation complete with captioning and special effects. Furthermore, if the digital camcorder is also 1394 compliant, it can download the data directly to the PC by way of a 1394 port on the PC. The PC can then save the data to a regular internal hard drive.

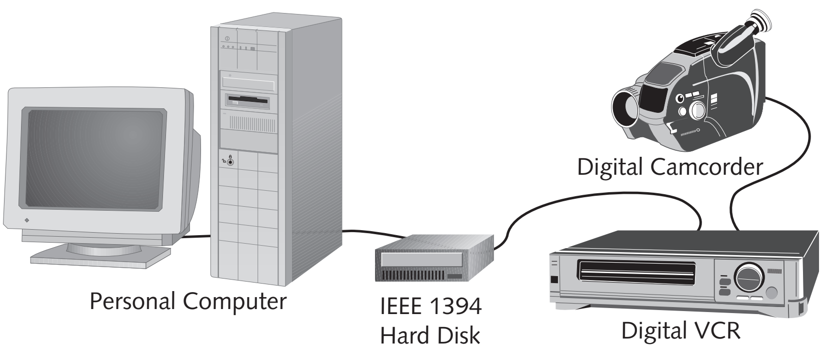


Figure 9-20 IEEE 1394 can be used as the interface technology to connect consumer audio/visual equipment to a PC

The current standard for IEEE 1394 is IEEE 1394.A, which supports speeds of 100, 200, or 400 Mbps, allows for cable lengths up to 4.5 meters, and is hot-pluggable. **Hot-pluggable** means that you can plug in a 1394 device without rebooting your PC and remove the device without receiving an error message. A new standard under development, IEEE 1394.B will support speeds up to 3.2 gbps (gigabits per second) and extend the maximum cable length to 100 meters.

A+CORE 1.7

Windows 98 and Windows 2000 support IEEE 1394. Windows 98 Second Edition supports storage devices, but IEEE 1394 printers and scanners are not supported. Windows 2000 supports all these devices. For Windows 98 Second Edition, you can download an update from the Microsoft web site (*windowsupdate.microsoft.com*). The update solves previous problems when devices are removed while the PC is still running.

To use a 1394 port, follow these steps:

1. Verify that Windows 98 recognizes that an IEEE 1394 controller is present on the system board. Just as with the USB controller, using Device Manager, look for the 1394 Bus Controller listed as an installed device. Click the **+** sign beside the controller in Device Manager to see the specific brand of 1394 controller that the board contains. If the controller is not installed or is not working, then reinstall the driver. In the Control Panel, double-click the **Add New Hardware** icon. If you have problems installing the driver, verify that 1394 support is enabled in setup.
2. Plug the device into the 1394 port. Install the device drivers for the 1394-compliant device. For example, for a Sony camcorder, insert the CD that contains supporting software in the CD-ROM drive and execute **D:\Setup.exe** from the Run dialog box. When the device is plugged in and the drivers are installed, you should see the device listed in Device Manager under Sound, video and game controllers. If you don't see the device listed, turn the camcorder off and back on.
3. Install the applications software to use the device. A 1394-compliant camcorder is likely to come bundled with video editing software. Run the software to use the device.

For system boards that don't support IEEE 1394, you can install an IEEE 1394 host adapter to provide the support. For example, FireBoard by Unibrain, Inc. uses a PCI expansion slot and follows the IEEE 1394.A standard. See *www.unibrain.com*.

9

Using PCI Expansion Slots

A+CORE 4.3, 4.4

Recall from Chapter 3 that the PCI bus is a local bus that runs in sync with the CPU. The PCI slots are often white (see Figure 1-17 in Chapter 1), which easily distinguish them from the black ISA slots on the board. Because the PCI bus is faster than the ISA bus, PCI slots are often used for fast I/O devices such as a network card or SCSI host adapter. The PCI bus master, which is part of the system board chip set, manages the PCI bus and the expansion slots. The PCI bus master assigns IRQ and I/O addresses to PCI expansion cards, which is why you don't see jumpers or DIP switches on these cards. To be more accurate, the PCI bus assigns resources to a PCI slot; move the card to a different slot to assign new set of resources to it.

TIP

When installing a PCI card, most likely you do not need to configure the IRQ or I/O address for the card, because the startup BIOS and PCI bus controller do this for you.

A+CORE 4.3, 4.4

The PCI bus uses an interim interrupt between the PCI card and the IRQ line to the CPU. There are four of these interrupts, which PCI documentation calls A, B, C, and D. One interrupt is assigned to each PCI expansion slot. The PCI bus master then maps each of these internal PCI bus interrupts to IRQs, using IRQs that are available after legacy ISA bus devices have claimed their IRQs. The startup BIOS records which IRQs have been used by ISA devices and then assigns the unused ones to the PCI bus master during the boot process. In order for this to work, the system BIOS must be PCI-compliant. (Look for PCI on the BIOS chip; see Figure 1-24 of Chapter 1.)

Use Device Manager to see which IRQ has been assigned to a PCI device. For example, for Windows 95, Release 1, Figure 9-21 displays the resources assigned to a PCI video card. Notice that the IRQ assigned to the card is IRQ 9.

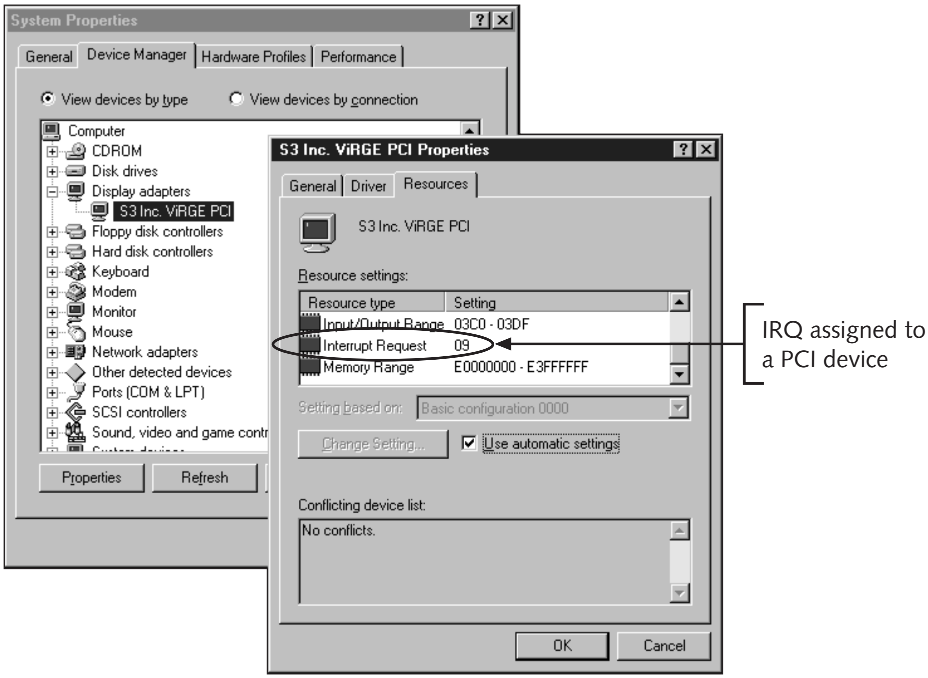


Figure 9-21 Use Device Manager to determine what IRQ has been assigned to a PCI device

Sometimes BIOS gives the PCI bus master an IRQ that a legacy ISA device needs, which can prevent either device from working. In CMOS setup, you can specify which IRQ to assign to a PCI slot, or you can tell setup that a particular IRQ is reserved for a legacy device, and thereby prevent the PCI bus from using it. See Figure 9-22.

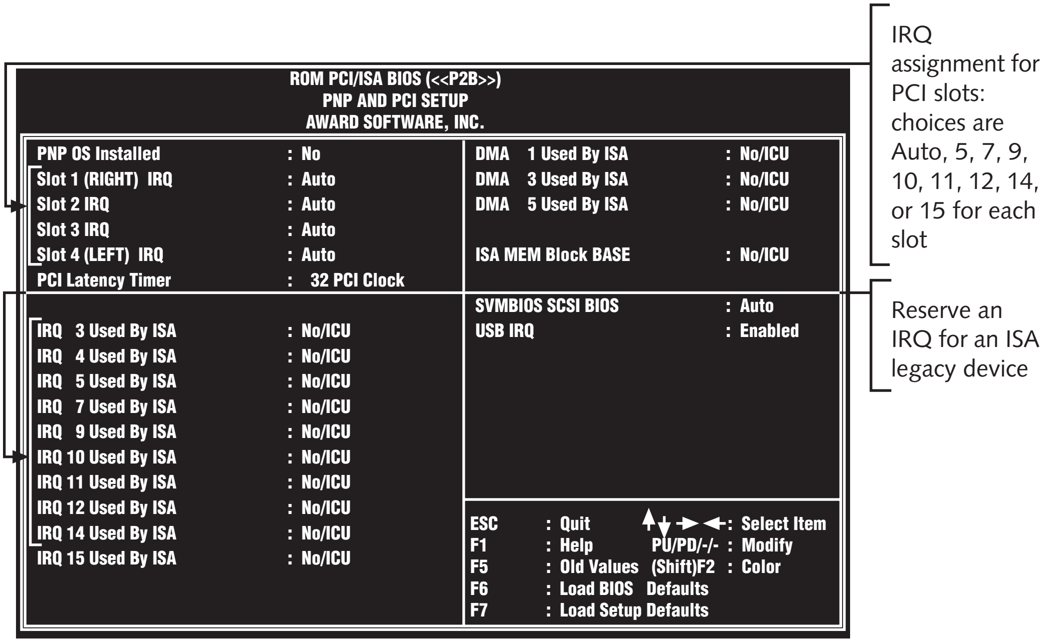


Figure 9-22 CMOS setup screen for Plug and Play and PCI options

A+ OS 3.2 CORE 4.4

PCI Bus IRQ Steering

PCI 2.1 specifications support **PCI bus IRQ steering**, a feature making it possible for PCI devices to share an IRQ, which can help solve the problem of not having enough IRQs to support all devices in a system. In order for the system to use the feature, both the system board BIOS and Windows must support it. During booting, startup BIOS records the IRQs used by ISA devices and the PCI bus in a table that Windows can read later when reassigning IRQs. Windows 95, release 2, (OSR2) and Windows 98 support PCI bus IRQ steering.

Sometimes an IRQ conflict can happen when startup BIOS is not aware that a legacy (not Plug and Play) ISA device is using a certain IRQ and assigns that IRQ to the PCI bus, which assigns it to a PCI device. With PCI bus IRQ steering, Windows can sometimes resolve the problem by reassigning another IRQ to the PCI bus, allowing the legacy device to be the sole owner of its IRQ.

In order to make this happen, Windows must detect an unused IRQ that it can use for the substitution. It then puts a holder on the IRQ, meaning that it reserves this IRQ for PCI only. The IRQ is no longer available for an ISA device as long as Windows has the holder on it. See Figure 9-23 for one example.

PCI bus IRQ steering can cause a particular problem. If Windows puts a holder on an IRQ, it might cause the PCI device using it to have problems. Also, if two PCI devices are having conflicts, sometimes PCI bus IRQ steering can mask the problem, making it difficult to diagnose. Finally, PCI bus IRQ steering can erroneously put a hold on an IRQ that is being used by an ISA device. Figure 9-24 shows an example of this, where IRQ 10 is needed by an Adaptec SCSI host adapter, but PCI steering has put a hold on the IRQ. In this case, you can

A+ OS 3.2

either claim IRQ 10 for the SCSI host adapter in CMOS setup (refer back to Figure 9-22) or you can disable PCI bus IRQ steering.

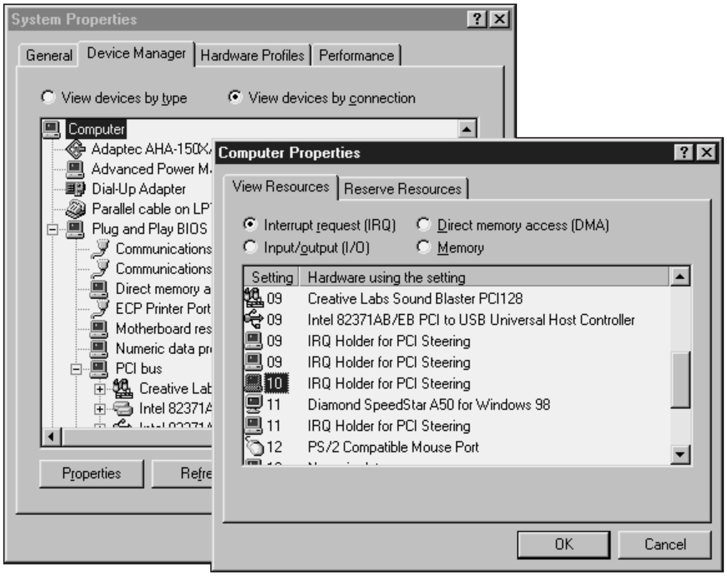


Figure 9-23 PCI bus IRQ steering has placed a holder on IRQ 10, making it unavailable to ISA devices

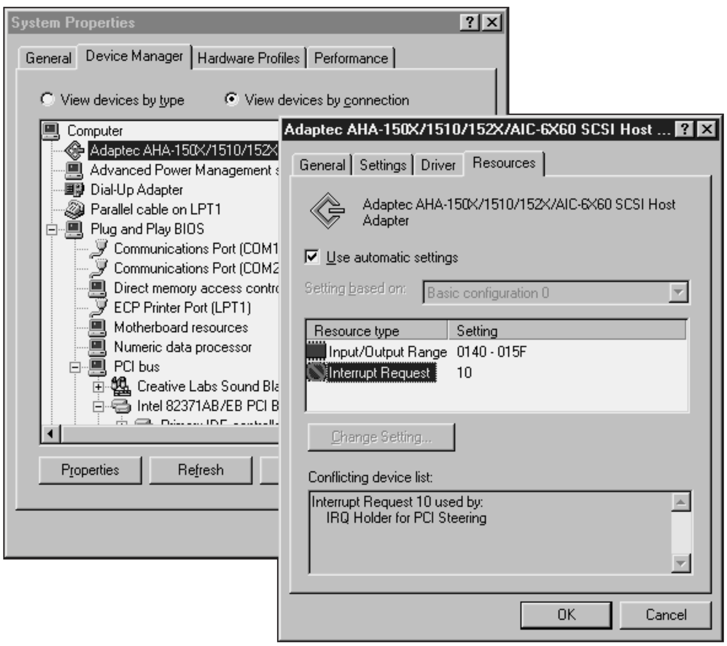


Figure 9-24 A conflict with IRQ 10 is caused by PCI steering putting a hold on the IRQ

A+ OS 3.2

> **TIP** Sometimes problems with resource conflicts can be solved by enabling PCI bus IRQ steering, and sometimes they can be resolved by disabling the feature!

To either enable or disable PCI bus IRQ steering, use Device Manager. Do the following:

1. Click **Start**, **Settings**, **Control Panel**. Double-click the **System** icon. Select the **Device Manager** tab.
2. Select **View device by connection**. Select **PCI bus** and click **Properties**. The PCI bus Properties dialog box is displayed.
3. Select the **IRQ Steering** tab, as shown in Figure 9-25 for Windows 98.
4. To enable or disable PCI bus IRQ steering, use the check box beside **Use IRQ Steering**.

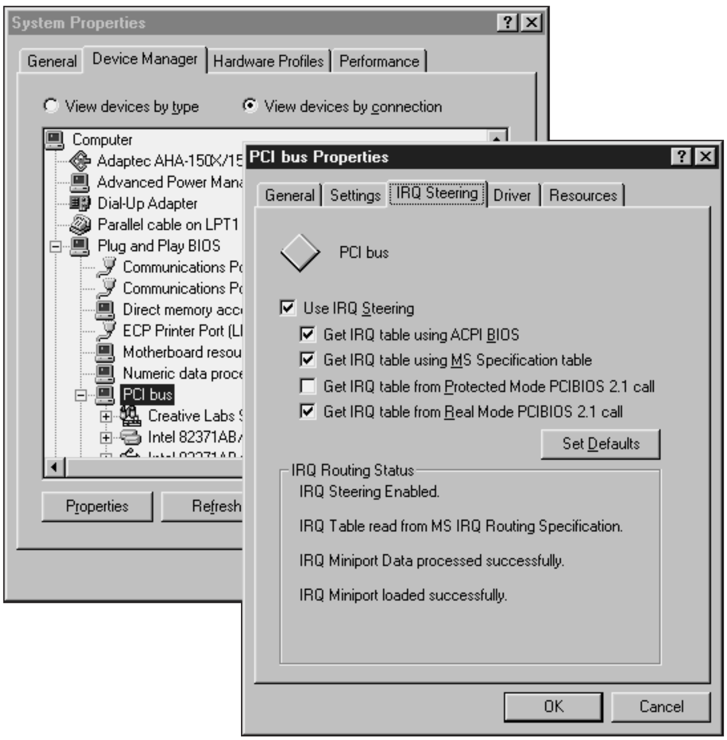


Figure 9-25 To enable or disable PCI bus IRQ steering, use the Properties box of the PCI bus

Using ISA Expansion Slots

Using legacy ISA bus devices is a little more difficult than using either USB or PCI, because the configuration is not as automated. The ISA bus itself does not manage the system resources, as do the USB and PCI bus masters. It is up to the ISA device to request system resources at startup. If the ISA device does not support Windows 9x Plug and Play, then you select the I/O address, DMA channel, and IRQ by setting jumpers or DIP switches on the card. If the ISA device is Plug and Play compliant, then at startup Windows 9x Plug and Play allocates the required resources to the device. To know if a device is Plug and Play compliant, look for "Ready for Windows 95" or "Ready for Windows 98" on the box, or read the documentation. You will learn more about this in Chapter 12.

When Device Installations Create Problems

A+ CORE 2.1

Suppose you install a new sound card and it does not work. If you also discover that your network card has stopped communicating, it is likely the two devices have a resource conflict. Other problems also can prevent these devices from working, such as a poorly seated circuit card or a loose cable. Check all connections carefully before proceeding. You might also remove the sound card, and check that your network is working. You can then conclude that you most probably have a conflict.

The place to begin to diagnose a conflict is with the documentation. Read everything carefully, looking for what has been discussed earlier in this chapter. What IRQ, I/O address, DMA channel, or upper memory addresses does the device being installed use? What does your network card use? Compare the two, and you will discover your conflict. The fix might be easy, or it might be impossible if neither board offers alternatives. Fortunately, most devices today offer alternate choices for these settings. Again, read the documentation for directions. Plug and Play devices make this process much easier, but many devices today are still not Plug and Play compliant.

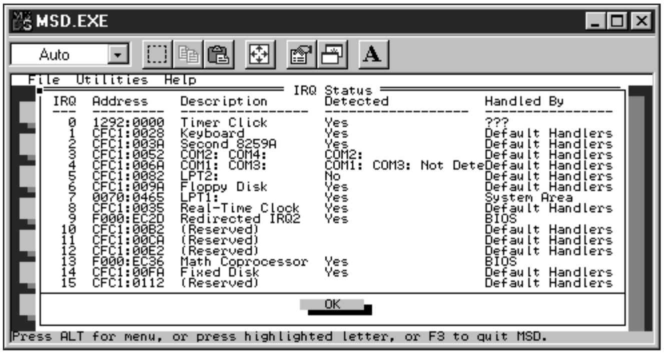
Resolving Resource Conflicts

When adding new devices to a system, probably the one most difficult problem you encounter is resolving a resource conflict, especially if the PC has several devices, some of which are not Plug and Play compliant. The two tools to use to help in resolving these conflicts are MSD in a DOS and Windows 3.x environment, and Device Manager in Windows 9x. However, neither of these tools is infallible because they both depend on what the OS knows about resources being used—and sometimes a device does not tell the OS what it's using. Follow this general approach when installing a new device:

1. Know the system resources already in use (see the documentation and/or use MSD or Device Manager).
2. Know what resources the new device will need (see the documentation).
3. Install the device using resources that are not already used by your system.
4. If you do have a conflict, use MSD, Device Manager, CMOS setup, and documentation for the system board and devices to first identify and then resolve the conflict.

A+CORE 2.1

To find out what resources are presently used by your system, for DOS and Windows 3.1, use the MSD diagnostics software. Figure 9-26 shows the results of displaying the IRQ settings. However, in the report in Figure 9-26, IRQs 10, 11, and 12 all have Reserved status. IRQ 11 and 12 are available, but on this computer, IRQ 10 is being used by a SCSI host adapter. MSD does not always tell all.



IRQ	Address	Description	Detected	Handled By
0	1292:0000	Timer Click	Yes	???
1	CFC1:0028	Keyboard	Yes	Default Handlers
2	CFC1:003A	Second 8259A	Yes	Default Handlers
3	CFC1:0052	COM2: COM4:	COM2:	Default Handlers
4	CFC1:006A	COM1: COM3:	COM1: COM3: Not Dete	Default Handlers
5	CFC1:0082	LPT2:	No	Default Handlers
6	CFC1:009A	Floppy Disk	Yes	Default Handlers
7	0070:0465	LPT1:	Yes	System Area
8	CFC1:0035	Real-Time Clock	Yes	Default Handlers
9	F000:EC2D	Redirected IRQ2	Yes	BIOS
10	CFC1:00B2	(Reserved)		Default Handlers
11	CFC1:00CA	(Reserved)		Default Handlers
12	CFC1:00E2	(Reserved)		Default Handlers
13	F000:EC36	Math Coprocessor	Yes	BIOS
14	CFC1:00FA	Fixed Disk	Yes	Default Handlers
15	CFC1:0112	(Reserved)		Default Handlers

Figure 9-26 MSD report of IRQ settings

To know the full story, also depend on your knowledge of the system and the records you have kept in the notebook dedicated to this PC.

To find out what resources your system is using, for Windows 9x, follow the steps below.

1. Click **Start**, point to **Settings**, click **Control Panel**, **System**, and then **Device Manager**. Click **Computer** and then **Properties**. Select the **View Resources** tab. The window in Figure 9-23 is displayed, showing the IRQs currently in use.
2. Select **Input/output (I/O)** to display a list of I/O addresses currently in use (see Figure 9-27). Note that the keyboard is currently assigned the I/O address of 60h.
3. Select **Memory** to display the current upper memory addresses in use by devices. The A, B, and C range of upper memory addresses are normally reserved for video. The F range is reserved for system BIOS. Not all the memory addresses actually in use are listed on this screen, only those that are directly requested by a working hardware device.

Once you have found the conflicting resource, try these things to resolve the conflict:

- If the device is a legacy ISA device, physically set the device's jumpers or DIP switches to use a different resource.
- If a legacy device can only use one IRQ, then use CMOS setup to reserve that IRQ for the device.
- If your PC supports PCI bus IRQ steering, enable the feature. That alone might solve the problem.
- Using PCI bus IRQ steering, tell Windows 98 to use a different IRQ for a PCI device. To do that, use the Properties box for the device in Device Manager.

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A+ CORE 2.1

- Use CMOS setup to assign a specific IRQ to a PCI device.
- Move the PCI device to a different slot, which will cause the PCI bus to assign a different resource to the device.
- Disable PCI bus IRQ steering.

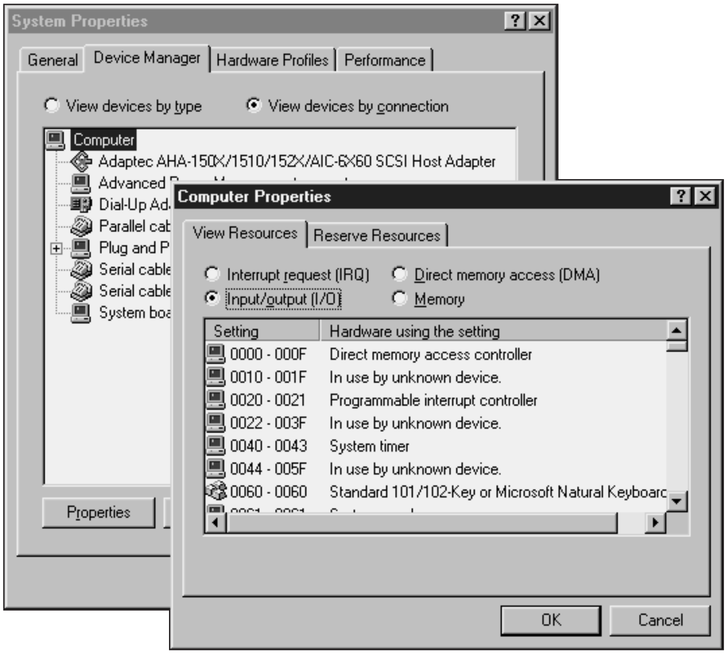

Figure 9-27 Use Device Manager to see I/O addresses currently in use

SCSI Devices

A+ CORE 4.3, 1.6

The SCSI bus was first introduced in Chapters 6 and 7 as it pertained to hard drives. This section looks at SCSI as a bus that can support other devices. Installing a SCSI device is normally accomplished in one of two ways:

- Install the SCSI device using a simplified version of a SCSI host adapter designed to accommodate one or two devices. These adapters often come bundled in the SCSI device package.
- Install the SCSI device on an existing or new host adapter designed to handle several devices.

Matching the Host Adapter to the SCSI Devices It Supports

When selecting a SCSI host adapter or determining if an existing host adapter will work with a new SCSI device, consider the issues described below.

A+ CORE 4.3, 1.6

SCSI standard In Chapter 6, you saw that there are several SCSI standards, including SCSI-1, SCSI-2, SCSI-3, Fast SCSI, Wide Ultra SCSI, and Ultra 160 SCSI. SCSI-1, SCSI-2, and Fast SCSI use a 50-pin connection. All wide SCSIs use a 68-pin connection. Your device should match the host adapter according to the number of pins on the connections. Also, your device and host adapter should have compatible standards.

The host adapter must be made for the correct expansion slot The host adapter must fit the expansion slot you plan to use. SCSI host adapters are made for 8-bit ISA, 16-bit ISA, 16-bit MCA, 32-bit MCA, 32-bit EISA, VL-Bus, and PCI buses. For a Pentium system board, you probably can choose either a 16-bit ISA host adapter or a PCI host adapter. Choose the 32-bit PCI bus for faster data transfer rate, instead of the 16-bit ISA bus.

Bus mastering Choose a host adapter that uses bus mastering, discussed in Chapter 3, if your system bus supports it. For PCI buses that do support bus mastering, you have the added advantage that, when bus mastering is used, the SCSI host adapter does not require a DMA channel.

A host adapter that supports several SCSI standards A host adapter that supports both 50-pin connections, 68-pin connections, and several standards allows you to choose a variety of devices without having to purchase a second host adapter.

Device driver standard Select a host adapter that supports one of the two leading driver standards for SCSI, either the ASPI or the CAM standard. ASPI, a standard developed by Adaptec, a leading SCSI manufacturer, is probably the better known of the two. ASPI (Advanced SCSI Programming Interface) or CAM (Common Access Method) describes the standard for the way the host adapter communicates with the SCSI device driver. The ASPI or CAM standard has nothing to do with the SCSI-1, SCSI-2, or SCSI-3 types, but rather with the way the drivers are written. Be sure that the host adapter and all the device drivers meet the same standard. As shown in Figure 9-28, the ASPI or CAM standard also affects the way the host adapter relates to the OS. For Windows 9x, the SCSI driver is built-in, but many host adapters provide their own host adapter drivers to be used by Windows 9x, and by DOS with Windows 3.x. The manufacturer of the host adapter usually provides the SCSI driver on floppy disk or CD-ROM.

Single-ended and differential SCSI Select a host adapter that matches the devices according to electronic signaling method. The two choices are single-ended SCSI devices and differential SCSI devices. Single-ended devices use single-ended cables and differential devices use differential cables. You cannot mix the two types of cables in the same system. Of the two, differential cables are more dependable. See Table 6-2 of Chapter 6 for details about cable length and maximum number of devices. Don't mix the two types of devices on the same SCSI system or use a host adapter that does not match. You can damage the devices if you do.

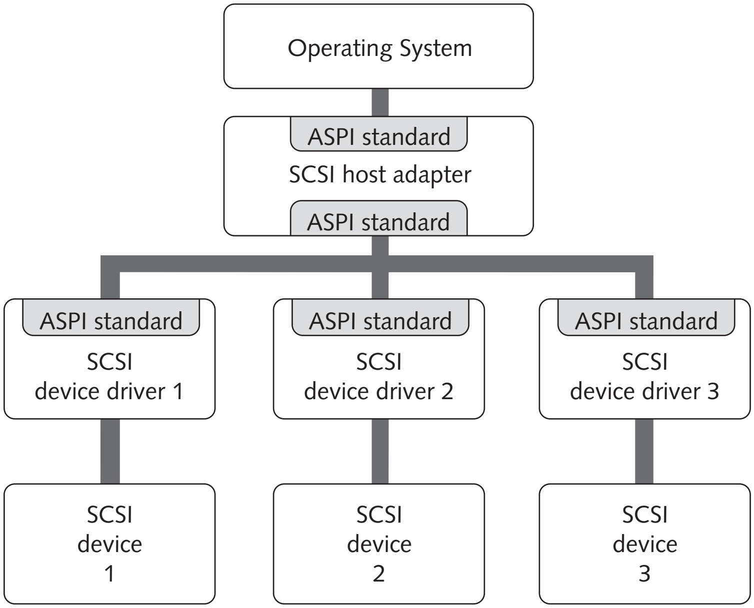

Figure 9-28 A SCSI device driver standard affects the interaction of the host adapter with the device drivers and the OS

SCAM-compliant SCAM (SCSI Configuration AutoMatically or SCSI Configuration AutoMagically, depending on the literature you're reading) is a method by which SCSI devices and the host adapter can be Plug and Play compliant. SCAM-compliant host adapters and devices can assign SCSI IDs dynamically at startup. Most SCSI devices currently in use are not SCAM compliant, and you will need to set the unique ID on the device, using jumpers, rotary dials, or other methods. Newer SCSI host adapters use software that comes with the card to configure the SCSI BIOS. With the software, you can set the SCSI IDs, SCSI parity checking, termination, and system resources used by the card.

There are two levels of SCAM. Level 1 requires that the devices, but not the host adapter, be assigned an ID at startup by software. Level 2 requires that the host adapter, as well as the devices, be assigned an ID at startup by software. SCSI-2 devices must be SCAM compliant to carry the logo "Designed for Windows 95" or "Designed for Windows 98."

A Sample Host Adapter for a Single Device

A+ CORE 1.6

In the first example below, you look at installing a typical host adapter designed to be used by a single external device and one or more internal devices. In this case, you are installing the Adaptec 1505 ISA-to-SCSI host adapter that is Plug and Play compliant. It has one external 25-pin SCSI connection and one internal 50-pin connection and is shown in Figure 9-29. The card comes with software to control its BIOS that is run from a bootable floppy disk included with the card. A single jumper on the card can be used to control the I/O addresses assigned to the card if system BIOS is not Plug and Play compliant.

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The card supports only one external device, hence the 25-pin connection; it uses only 25 of the 50 pins of the SCSI cable. The card comes with one 50-pin internal cable that has connections for the host adapter and two devices. The package also includes a 25-pin external cable for external devices.

Termination is achieved by three sets of sockets on the card that must be filled by three terminating resistors. One resistor is removed from a socket and is shown beneath the card. If you are installing both internal and external devices, remove all three resistors from the sockets and store them in a safe place. If you are only installing an external device or an internal device, but not both, then the host adapter is at the end of the SCSI chain and the three resistors should be in place.

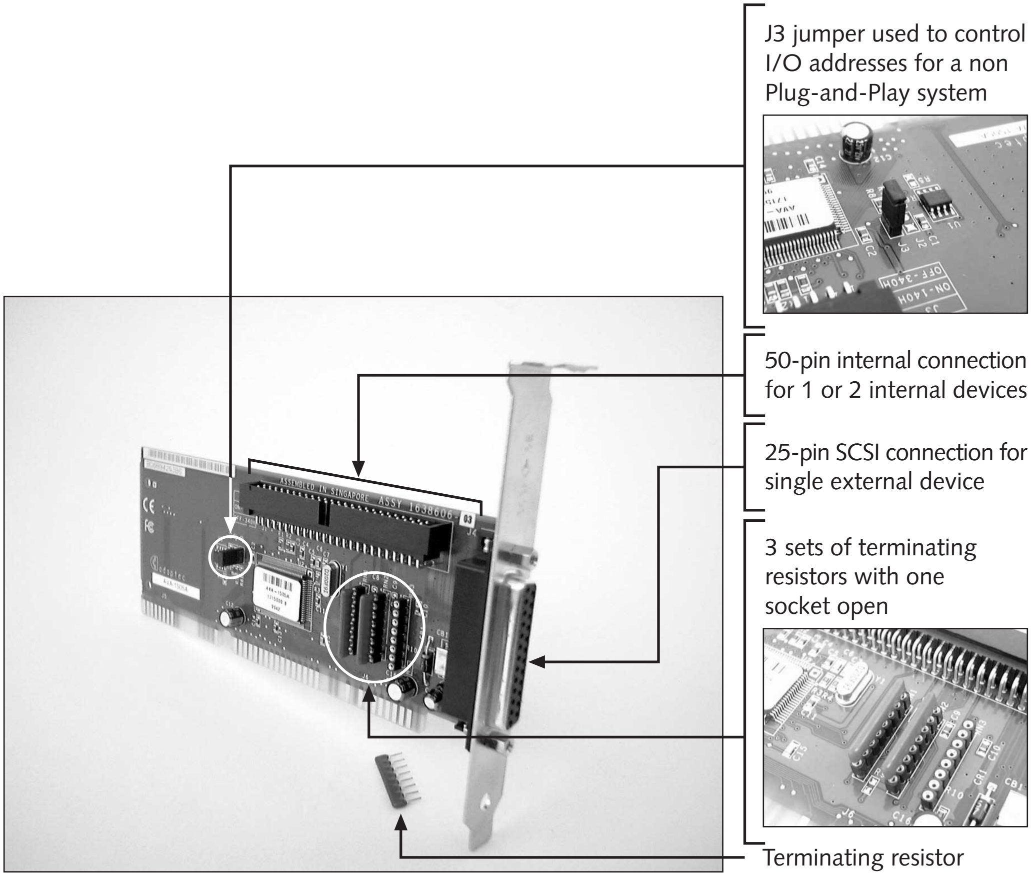

Figure 9-29 SCSI host adapter for a single external and multiple internal devices

A+ CORE 1.6

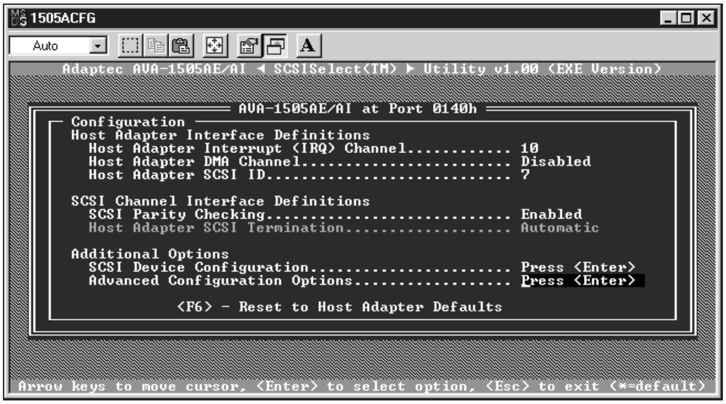

Figure 9-30 Setup software included with a SCSI host adapter is used to change SCSI BIOS settings on the card

For a Plug and Play system using Windows 98, follow these general steps to install this host adapter:

- Install the card in an ISA expansion slot.
- In most cases, the default settings for the host adapter are the correct ones, but you can change or verify these settings using the setup program on floppy disk. To use the setup program, boot the PC from the floppy disk included with the card. The disk boots the system (using DOS) and automatically executes the SCSI setup program. The two options on the opening menu are SCSI Disk Utilities (for installing a SCSI hard drive) and Configure the Host Adapter. Select **Configure the Host Adapter**. You see the host adapter configuration screen. See Figure 9-30.
- Verify the settings. Under the Advanced Configuration Options in Figure 9-30, you see two settings: enable or disable Plug and Play, and enable or disable SCAM support. Both are normally set to enable. Note in Figure 9-30 that the SCSI ID for the host adapter is 7 and that parity checking is enabled. After verifying settings, exit the setup program, remove the floppy disk, and reboot.
- When Windows 9x loads, it senses a new hardware device and automatically launches the Add New Hardware Wizard. Because Windows supports the host adapter, it loads the device drivers automatically and installs the host adapter.

To verify that the host adapter is correctly installed, click **Start**, **Settings**, **Control Panel**, and double-click **System**. Select **Device Manager**. Double-click **SCSI controllers**. The Adaptec host adapter should be displayed, as shown in Figure 9-31. Notice in the figure the broken diamond icon that stands for SCSI. Select the host adapter and click **Properties** to display the host adapter Properties dialog box also shown in Figure 9-31. Click the **Resources** tab to note the resources assigned the card by Plug and Play.

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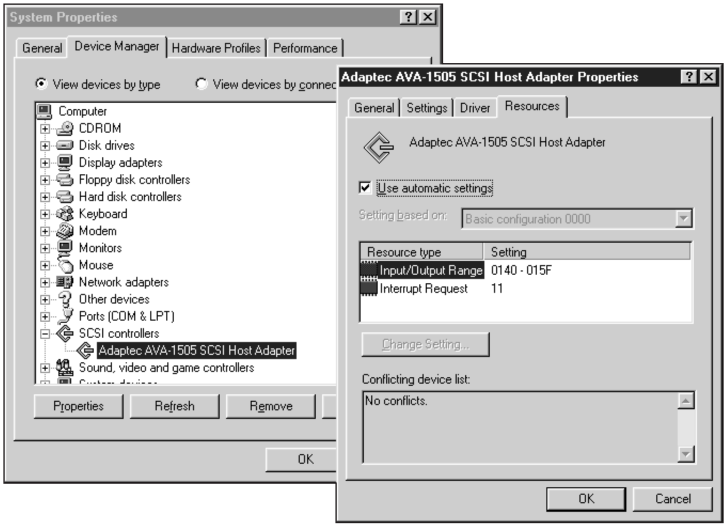

Figure 9-31 Device Manager displays the newly installed host adapter

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After you have installed the host adapter, you are ready to install the external SCSI device. For example, if the device is a SCSI scanner, follow these directions:

1. Install the software to run the scanner, which will include the scanner driver.
2. Plug the SCSI cable into the host adapter port.
3. Plug the other end of the cable into the scanner.
4. Set the SCSI ID on the scanner.
5. Connect the scanner's power cord to a wall outlet, and turn the scanner on.
6. Restart your PC and test the scanner.

KEYBOARDS

In the rest of the chapter, we look at the essential I/O devices for a PC: the keyboard, a pointing device, and video display.

Keyboards have either a traditional straight design or a newer ergonomic design, as shown in Figure 9-32. The word "ergonomic" means designed for safe and comfortable interaction between human beings and machines. The ergonomically safer keyboard is designed to keep your wrists high and straight. Some users find it comfortable, and others do not. Figure 9-33 demonstrates the correct position of hands and arms at the keyboard. Keyboards also differ in the feel of the keys as you type. Some people prefer more resistance than others, and some like more sound as the keys make contact. A keyboard might have a raised bar or circle on the F and J keys to help your fingers find the home keys as you type. Another feature is the depth of the ledge at the top of the keyboard that holds pencils, etc. Some keyboards have a

mouse port on the back of the keyboard, and specialized keyboards have trackballs or magnetic scanners for scanning credit cards in retail stores.

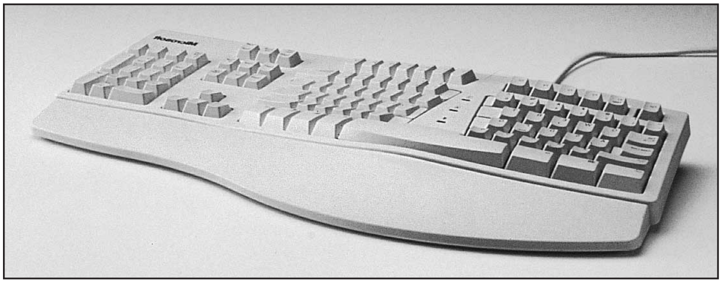

Figure 9-32 An ergonomic keyboard

Figure 9-33 Keep wrists level, straight, and supported while at the keyboard

Computer keyboards have been criticized by users who work with them for hours at a time because they can cause a type of repetitive stress injury (RSI) known as carpal tunnel syndrome (CTS). CTS is caused by keeping the wrists in an unnatural position and having to execute the same motions (such as pressing keys on a keyboard) over prolonged periods.

You can help prevent carpal tunnel syndrome by keeping your elbows at the same level as the keyboard and keeping your wrists straight and higher than your fingers. I've found that a keyboard drawer that slides out from under a desk surface is much more comfortable, because the keyboard is low enough for me to keep a correct position. If I'm working at a desk with no keyboard drawer, I sometimes type with the keyboard in my lap to relieve the pressure on my arms and shoulders.

Keyboard manufacturers use one of two common technologies in the way the keys make contact: foil contact or metal contact. With a foil-contact keyboard, when you press a key, two layers of foil make contact and close a circuit. A small spring just under the keycap raises the key again after it is released.

Metal-contact keyboards are more expensive and heavier, and generally provide a different touch to the fingers than foil keyboards. Made by IBM and AT&T, as well as other companies, the metal-contact keyboards add an extra feel of quality that is noticeable to most users, giving the keystroke a clear, definitive contact. When a key is pressed, two metal plates make contact, and a spring is again used to raise the key when it is released.

Keyboard Connectors

A+ CORE 1.4

Keyboards connect to a PC by one of three methods: a PS/2 connector (sometimes called a mini-DIN), a DIN connector, or, more recently, a USB port. The DIN connector (DIN is an acronym of the German words meaning German industry standard) is round and has five pins. The smaller round PS/2 connector has six pins. See Figure 9-34. Table 9-6 shows the pinouts (position and meaning of each pin) for both connector types. If the keyboard you are using has a different connector than the keyboard port of your computer, use a keyboard connector adapter, like the one shown in Figure 9-35, to convert DIN to PS/2 or PS/2 to DIN. Also, some keyboards are cordless, using radio transmission to communicate with a sensor connected to the keyboard port. For example, a cordless keyboard made by Logitech uses a sensor that plugs into a normal keyboard port. (See *www.logitech.com*.)

Table 9-6 Pinouts for keyboard connectors

Description	6-Pin Connector (PS/2)	5-Pin Connector (DIN)
Keyboard data	1	2
Not used	2	3
Ground	3	4
Current (+5 volts)	4	5
Keyboard clock	5	1
Not used	6	–

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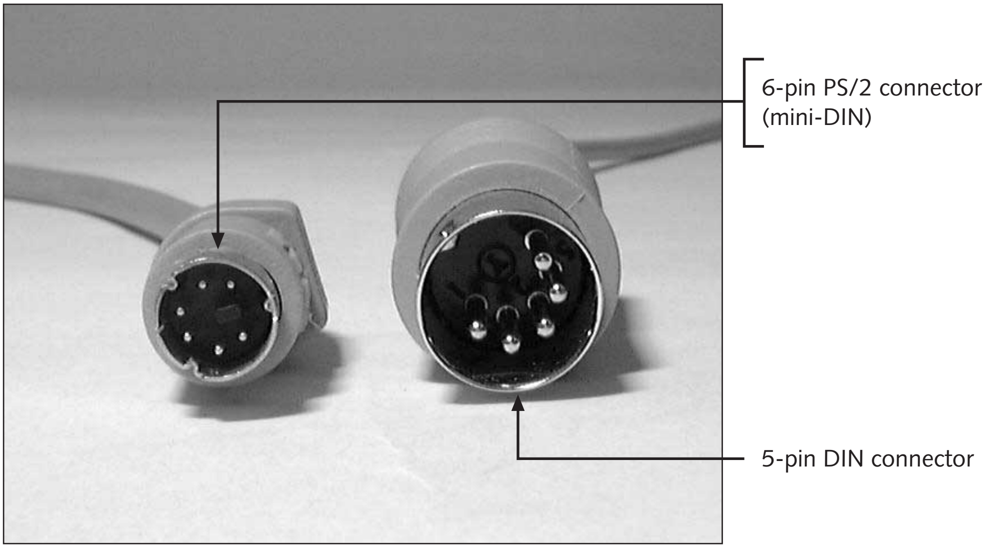

Figure 9-34 Two common keyboard connectors are a PS/2 connector and a DIN connector

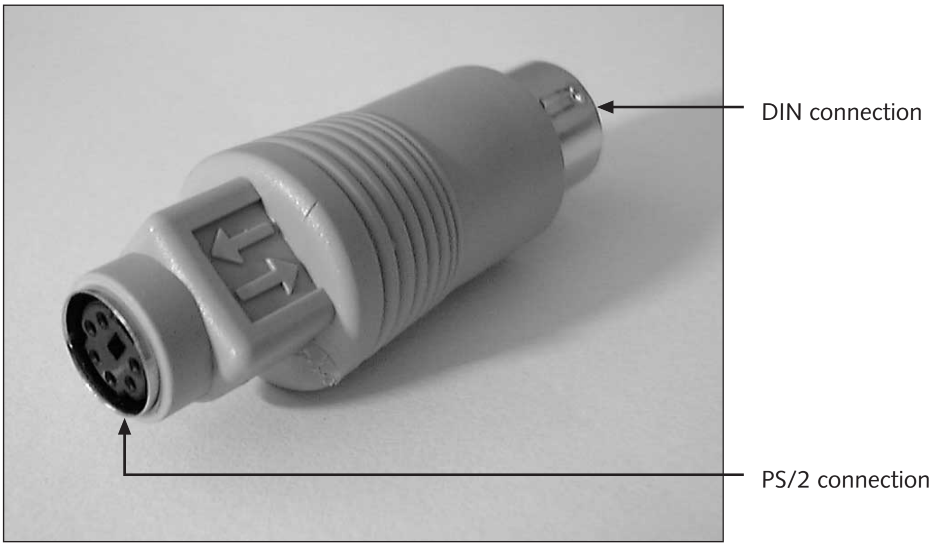

Figure 9-35 A keyboard adapter

Regardless of the type of connection or the construction of the keyboard, when a key is pressed, the same logical progression occurs. First, a code is produced called the **make code**. Releasing the key produces the **break code**. A chip in the keyboard processes these codes to produce a scan code that is sent to the CPU. The chip determines the location of the key pressed and sends that location together with the IRQ to the CPU. The scan code is temporarily stored in memory. The keyboard driver, which is most often stored in the system

BIOS, converts the scan code to the character assigned to that code, according to the keyboard driver selected. The different drivers available to interpret scan codes vary by language.

POINTING DEVICES

A device that allows you to move a pointer on the screen and perform tasks such as executing (clicking) a command button in applications software is called a pointing device. Common pointing devices are the mouse, the trackball, and touch pads (see Figure 9-36).

Figure 9-36 The most common pointing devices: a mouse, a trackball, and a touchpad

The two mouse technologies include a wheel mouse and an optical mouse. Inside a wheel mouse is a ball that moves freely as you drag the mouse on a surface. As shown in Figure 9-37, two or more rollers on the sides of the ball housing turn as the ball rolls against them. Each roller turns a wheel. The turning of the wheel is sensed by a small light beam as the wheel "chops" the light beam when it turns. The chops in the light beams are interpreted as mouse movement and are sent to the CPU. One of two rollers tracks the x-axis (horizontal) movement of the mouse, and a second roller tracks the y-axis (vertical) movement.

An optical mouse replaces the ball in a standard mouse with a microchip, miniature red light, and camera. The light illuminates the work surface, the camera takes 1500 snapshots every second, and the microchip reports the tiniest changes to the PC. An optical mouse works on most surfaces and doesn't require a mouse pad. The bottom of an optical mouse has a tiny

hole for the camera rather than a ball and the light glows as you work. An example of an optical mouse is Intelli-Eye by Microsoft.

A mouse can have two or three buttons. Software must be programmed to use these buttons. Almost all applications use the left button. Windows 9x has made great use of the right button. The center button has recently been converted into a scroll wheel that you can use to move through large documents on screen.

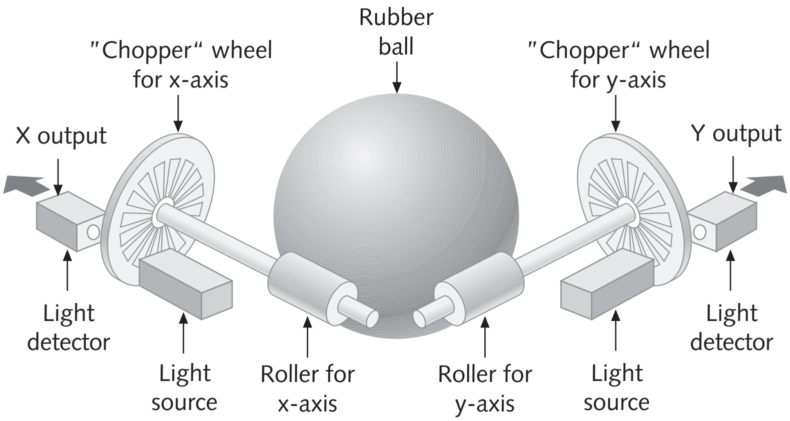

Figure 9-37 How a wheel mouse works

A+ CORE 1.2

A mouse can connect to the computer by several methods:

- By using the serial port (the mouse is then called a **serial mouse**)
- By using a dedicated round mouse port coming directly from the system board (**system-board mouse** or **PS/2-compatible mouse**)
- By using a mouse bus card that provides the same round mouse port (**bus mouse**) as discussed above
- By using the USB port
- By using a Y-connection with the keyboard so that both the keyboard and the mouse can share the same port
- By using a cordless technology whereby the mouse sends signals to a sensor on the PC

Except for the cordless mouse, all of the above produce the same results (that is, the mouse port type is "transparent to the user"). Therefore, the advantages and disadvantages of each connection type are based mainly on the resources they require. The system-board mouse is the first choice for most users because the port on the system board does not take up any resources that other devices might need. If you are buying a new mouse that you plan to plug into the system-board port, don't buy a bus mouse unless the system-board documentation states that you can use a bus mouse. The system-board port and the bus port are identical, but a bus mouse might not work on the system-board port.

A+ CORE 1.2

If you have a system-board port, use it. If it becomes damaged, you can switch to a serial port or bus port. The system-board mouse port will most likely use IRQ 12. If you are not using a mouse on this port, the system board might release IRQ 12 so that other devices can use it. Check the documentation for your system board to determine how the unused IRQ is managed.

The serial mouse requires a serial port and an IRQ for that port. Most people prefer a bus mouse over a serial port mouse because they can assign the serial ports to other peripheral devices. A bus mouse can use a bus card if the system board does not have a mouse port.

Cleaning the Mouse

A+ CORE 2.1, 3.1

The rollers inside the wheel mouse housing collect dirt and dust and occasionally need cleaning. Remove the cover to the mouse ball from the bottom of the mouse. The cover usually comes off with a simple press and shift or turn motion. Clean the rollers with a cotton swab dipped in a very small amount of liquid soap.

Other Pointing Devices

Another pointing device is a trackball, which is really an upside-down wheel mouse. You move the ball on top to turn rollers that turn a wheel sensed by a light beam. Touch pads allow you to duplicate the mouse function, moving the pointer by applying light pressure with one finger somewhere on a pad that senses the x, y movement. Some touch pads let you double-click by tapping their surface. Buttons on the touch pad serve the same function as mouse buttons. Use touch pads or trackballs where surface space is limited, because they remain stationary when you use them. Touch pads are popular on notebook computers.

Computer Video

The primary output device of a computer is the monitor. The two necessary components for video output are the video controller and the monitor itself.

Monitors

A+ CORE 1.1

The common types of monitors today are rated by screen size, resolution, refresh rate, and interlace features. Many older VGA (Video Graphics Adapter) monitors are still in use, but most sold today meet the standards for Super VGA. Monitors use either the older CRT (cathode-ray tube) technology used in television sets or the new LCD (liquid crystal display) technology used in notebook PCs and also available for desktop use. These LCD monitors for desktops are called **flat panel monitors**.

How a CRT Monitor Works

Most monitors use CRT technology, in which the filaments at the back of the cathode tube shoot a beam of electrons to the screen at the front of the tube, as illustrated in Figure 9-38. Plates on the top, bottom, and sides of the tube control the direction of the beam. The beam

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is directed by these plates to start at the top of the screen, move from left to right to make one line, and then move down to the next line, again moving from left to right. As the beam moves vertically down the screen, it builds the displayed image. By turning the beam on and off and selecting the correct combination of colors, the grid in front of the filaments controls what goes on the screen when the beam hits that portion of the line or a single dot on the screen. Special phosphors placed on the back of the monitor screen light up when hit and produce colors. The grid controls which one of three electron guns is fired, each gun targeting a different color (red, green, or blue) positioned on the back of the screen.

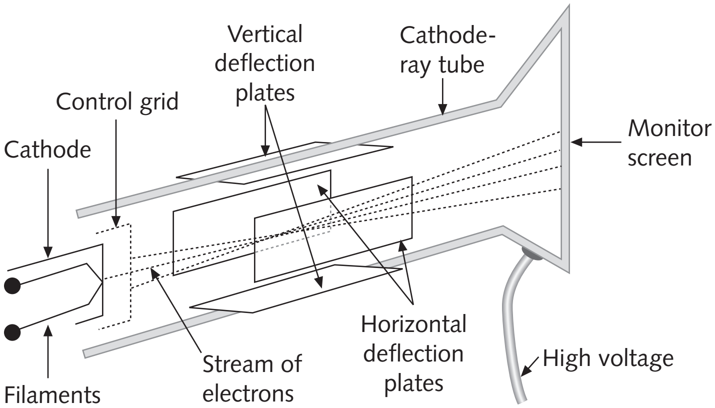

Figure 9-38 How a CRT monitor works

Choosing the Right Monitor

How a monitor works and what features are available on monitors are summarized in Table 9-7 and discussed next.

Table 9-7 Some features of a monitor

Monitor Characteristic	Description
Screen size	Diagonal length of the screen surface
Refresh rate	The number of times an electronic beam fills a video screen with lines from top to bottom in one second
Interlaced	The electronic beam draws every other line with each pass, which lessens the overall effect of a lower refresh rate.
Dot pitch	The distance between adjacent dots on the screen
Resolution	The number of spots, or pixels, on a screen that can be addressed by software
Multiscan	Monitors that offer a variety of refresh rates so they can support several video cards
Green monitor	A monitor that saves electricity and supports the EPA Energy Star program

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Screen Size

The screen size of a monitor is the one feature that most affects price. Common sizes of monitor screens are 14-inch, 15-inch, 17-inch, and 21-inch. The 15-inch monitor is the most popular, and the small 14-inch monitor is losing popularity.

When matching a monitor to a video card, a good rule of thumb is to match a low-end video card to a small, 14-inch monitor, a midrange video card to a 15-inch monitor, and a high-end video card to a 17-inch or larger monitor to get the best performance from both devices. However, you can compare the different features of the video card to those of the monitor, such as the resolutions supported, the refresh rate, and the bandwidth. **Bandwidth** is the difference between the highest and lowest frequencies that an analog communications device such as a video cable can carry.

Macintosh computers can use special monitors designed for page layouts on legal-sized paper. The larger the screen size, the more expensive the monitor. The monitor I'm now using is advertised as having a 17-inch screen. The actual dimensions of the lighted screen are 9½ inches by 11½ inches. The diagonal measurement of the lighted area is 15 inches, and the diagonal measurement of the screen surface is 17 inches.

Refresh Rate

The refresh rate, or vertical scan rate, is the number of times in one second an electronic beam can fill the screen with lines from top to bottom. Refresh rates differ among monitors. The Video Electronics Standards Association (VESA) has set a minimum refresh rate standard of 70 Hz, or 70 complete vertical refreshes per second, as one requirement of Super VGA monitors. Slow refresh rates make the image appear to flicker while faster refresh rates make the image appear solid and stable.

Interlaced or Noninterlaced

Interlaced monitors draw a screen by making two passes. On the first pass, the electronic beam strikes only the even lines, and on the second pass the beam strikes only the odd lines. The result is that a monitor can have a slow refresh rate with a less noticeable overall effect than there would be if the beam hit all lines for each pass. Interlaced monitors generally have slightly more flicker than **noninterlaced** monitors, which always draw the entire screen on each pass. Buy a noninterlaced monitor if you plan to spend long hours staring at the monitor. Your eyes will benefit.

Dot Pitch

The **dot pitch** is the distance between the spots, or dots on the screen that the electronic beam hits. Remember that three beams build the screen, one for each of three colors (red, green, and blue). Each composite location on the screen is really made up of three dots and is called a triad. The distance between a color dot in one triad and the same color dot in the next triad is the dot pitch. The smaller the pitch, the sharper the image. A dot pitch of .28 mm or .25 mm gives the best results and costs more, although less expensive monitors can have a

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dot pitch of .35 mm or .38 mm. These less expensive monitors with dot pitches of .35 mm or .38 mm can still create a fuzzy image even with the best video cards.

Resolution

Resolution is a measure of how many spots on the screen are addressable by software. Each addressable location is called a **pixel** (for picture element) which is composed of several triads. Because resolution depends on software, the resolution must be supported by the video controller card, and the software you are using must make use of the resolution capabilities of the monitor. The standard for most software packages is 800 by 600 pixels, although many monitors offer a resolution of 1024 by 768 pixels or higher. The resolution is set in Windows from the Control Panel and requires a driver specific for that resolution. Higher resolution usually requires more video RAM.

Multiscan Monitor

Multiscan monitors offer a variety of vertical and horizontal refresh rates so they can support a variety of video cards. They cost more but are much more versatile than other monitors.

Green Monitor

A "green" monitor is a monitor that saves electricity, thus making its contribution to conserving natural resources. A green monitor meets the requirements of the EPA Energy Star program and uses 100 to 150 watts of electricity. When the screen saver is on, the monitor should use no more than 30 watts of electricity.

Monitors and ELF Emissions

There is some debate about the danger of monitors giving off ELF (extremely low frequency) emissions of magnetic fields. Standards to control ELF emissions are Sweden's MPR II standard and the TCO '95 standards. The TCO '95 standards also include guidelines for energy consumption, screen flicker, and luminance. Most monitors manufactured today comply with the MPR II standard, and very few comply with the more stringent TCO '95 standards.

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Flat Panel Monitors

Increasing in popularity, though their cost is still three times that of comparable CRT monitors, are flat panel monitors, sometimes called flat panel display, that use LCD screens. See Figure 9-39. Flat panel monitors take up much less desk space than CRT monitors, are lighter, require less electricity to operate, and provide a clearer, more precise image. An LCD panel produces an image using a liquid crystal material made of large, easily polarized molecules. Figure 9-40 shows the layers of the LCD panel that together create the image. At the center of the layers is the liquid crystal material. Next to it is the layer responsible for providing the color to the image. These two layers are sandwiched between two grids of electrodes. One grid of electrodes is aligned in columns, and the other electrodes are aligned in rows. The two layers of electrodes make up the electrode matrix. Each intersection of a row electrode and a

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column electrode forms one pixel on the LCD panel. Software can manipulate each pixel by activating the electrodes that form it. The image is formed by scanning the column and row electrodes, much as the electronic beam scans a CRT monitor screen.

Figure 9-39 Flat panel display monitors use an LCD panel

The polarizer layers outside the glass layers in Figure 9-40 are responsible for preventing light from passing through the pixels when the electrodes are not activated. When the electrodes are activated, light on the back side of the LCD panel can pass through one pixel on the screen, picking up color from the color layer as it passes through.

There are two kinds of LCD panels on the market today: active-matrix and dual-scan passive matrix displays. A dual-scan display is less expensive than an active-matrix display and does not provide as high-quality an image. With dual-scan display, two columns of electrodes are activated at the same time. With active-matrix display, a transistor that amplifies the signal is placed at the intersection of each electrode in the grid, which further enhances the pixel quality.

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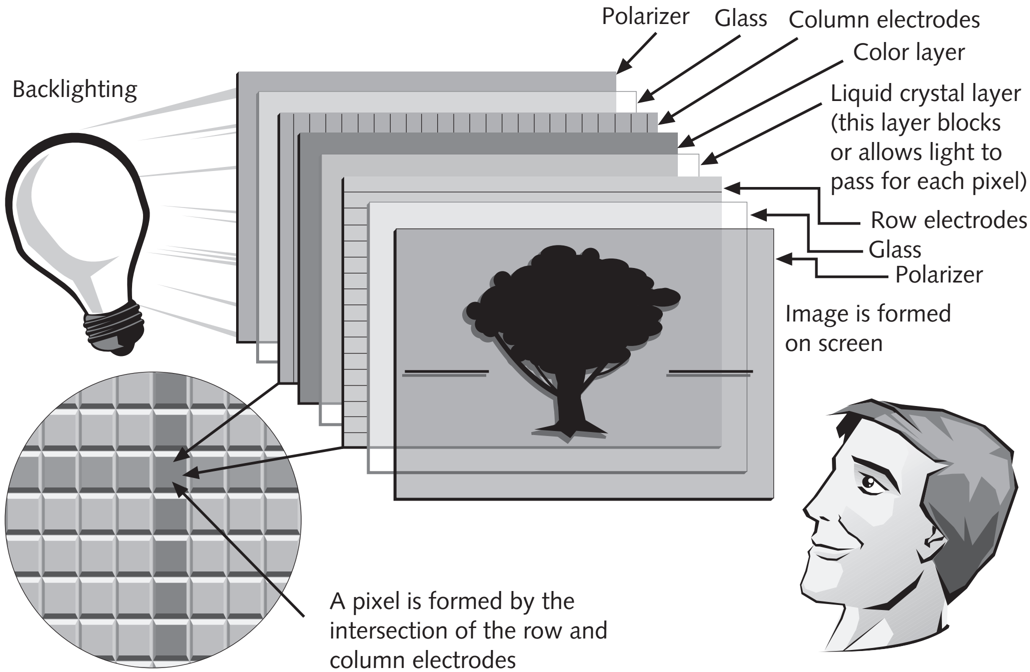

Figure 9-40 Layers of an LCD panel

Flat panel monitors are built to receive either an analog signal or a digital signal from the video card and have two ports on the monitor to accommodate either signal. If the signal is analog, it must be converted to digital before the monitor can process it. Flat panel monitors are designed to receive an analog signal so that you can use a regular video card that works with a CRT monitor, thus reducing the price of upgrading from a CRT to an LCD monitor. As you will see in the upcoming discussion of video cards, video cards convert digital data from the CPU to analog before sending it to the monitor. Therefore, with analog flat panel monitors, the data is converted from digital to analog and back to digital before being used by the flat panel monitor. These conversions reduce the quality of the resulting image. To get the best output, use a digital flat panel monitor along with a digital video card designed to support the monitor.

Video Cards

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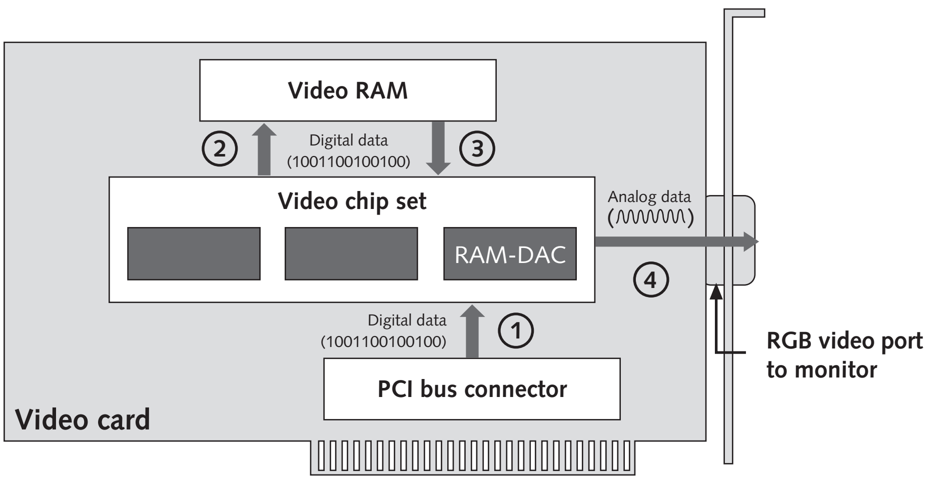
Recall that the video controller card is the interface between the monitor and the computer. These cards are sometimes called graphic adapters, video boards, graphics cards, or display cards. Sometimes the video controller is integrated into the system board. If you are buying a system board with this integrated video controller, check that you can disable the controller on the system board if it needs replacement or gives you trouble. You can then install a video card and bypass the controller on the system board.

The quality of a video subsystem of a computer system is rated according to how it affects overall system performance, video quality (including resolution and color), power-saving features, and ease of use and installation. Because the video controller is separated from the core system functions, manufacturers can use a variety of techniques to improve performance without being overly concerned with compatibility with functions on the system board. An example of this flexibility is seen in the many ways memory is managed on a video controller. This section discusses the features available on video cards, especially video memory. The two main features to look for in a video card are the bus it uses and the amount of video RAM it has or can support.

How a Video Card Works

A video card performs four basic tasks, as seen in Figure 9-41. The RAM DAC (digital-to-analog converter) technology may be housed on a single RAM DAC chip on the video card or may be embedded in the video chip set. RAM DAC actually includes three digital-to-analog converters, one for each of the monitor's three color guns: red, green, and blue (RGB).



Four Basic Functions of a Video Card
1 The digital data goes from the system bus to the video chip set on the video card.
2 The video chip set writes the digital data to video memory on the card.
3 The data stored in video memory is passed to the digital analog converter (RAM DAC), where it is converted from digital data to analog data.
4 RAM DAC passes the analog data to the monitor.

Figure 9-41 Four basic functions of a video card

The Bus Used by the Video Card

The speed and performance of a video card are partly a function of the bus that the card is using. Since 1995, video cards have been designed to use only the PCI bus and more recently

to use the AGP slot. Older video cards were made to run on VESA local buses (VL-bus), a proprietary local bus, ISA buses, and EISA buses.

Recall from Chapter 3 that the fastest bus for video on a system board today is AGP with a 32-bit-wide data bus, running at up to 1 GB/sec, depending on the AGP standard used. The regular AGP slot has 132 pins and AGP Pro has 188 pins. The added pins used by the AGP Pro standard provide voltage for high-end graphic accelerator cards discussed in the next section. After AGP, the PCI bus is next in throughput, providing either 132 or 264 MB/sec. If you play computer games or use extensive graphics software, such as that for CAD or desktop publishing, invest in a fast video card that uses a fast bus and has plenty of memory.

On the video card itself, performance is affected by the chip set, memory, and the RAM DAC, as well as by the bus speed and size. One method to improve performance is to allow both the video chip set and the RAM DAC (both the input and the output processes) to access video memory at the same time. This method, called **dual-porting**, requires a special kind of video RAM discussed later in this section. Another method of increasing performance is to place a processor on the video card, making the card a **graphics accelerator**.

The bus external to the video card is the PCI bus or the AGP bus, but the card itself also has an internal video bus. The volume of data that can travel on the bus is called bandwidth. Current video buses use a data path that may be 32 bits, 64 bits, 128 bits, or even 256 bits wide. The effective bandwidth of the bus is partly determined by the width of the data path and the amount of memory on the card.

Graphics Accelerators

One of the more important advances made in video cards in recent years has been the introduction of graphics accelerators. A graphics accelerator is a type of video card that has its own processor to boost performance. With the demands that graphics applications make in the multimedia environment, graphics accelerators have become not just an enhancement, but a common necessity.

The processor on a graphics accelerator card is similar to a CPU, but specifically designed to manage video and graphics. Some features included on a graphics accelerator are MPEG decoding, 3-D graphics, dual porting, color space conversion, interpolated scaling, EPA green PC support, digital output to flat panel display monitors, and applications support for popular high-intensity graphics software such as AutoCAD, Quark, Windows 9x, Windows NT, and Windows 2000. All these features are designed, in some way, to reduce the burden on the system board CPU and perform the function much faster than the system board CPU.

For more information about graphics accelerator cards, see these manufacturers at their web sites: ATI Technologies at *www.ati.com*, Matrox Graphics, Inc, at *www. matrox.com*, and 3-Dfx Interactive, Inc. at *www.3-Dfx.com* (makers of the popular Voodoo graphics card).

Video Memory

Older video cards do not have memory, but today they must so they can handle the large volume of data generated by increased resolution and color. Video memory is stored on

video cards as memory chips. The first video cards to have memory all used DRAM chips, but now video memory chips can use several technologies. This section discusses how much video memory is needed and what kinds of video memory chips can be used on a card for the best possible performance.

How Much Video Memory Is Needed?

The amount of data received by a video card from the CPU for each frame (or screen) of data is determined by the screen resolution (measured in pixels), the number of colors, which is called the **color depth** (measured in bits), and enhancements to color information called alpha blending. The more data required to generate a single screen of data, the more memory is required to hold that data. Recall that this memory is called the frame buffer. The video card has other needs for memory besides the frame buffer, including the memory used by some cards to store font or other graphical information. Aside from these other uses of memory, Table 9-8 shows the amount of memory needed to hold the frame buffer, which is determined by the screen resolution and number of colors.

Table 9-8 Video RAM required for different video resolutions and color depths

Video Resolution	4-bit Color Depth (16 colors)	8-bit Color Depth (256 Colors)	16-bit Color Depth (65,000 Colors)	24-bit True Color (16.7 Million Colors)	32-bit (24-bit True Color with 8-bit Alpha Channel)
640 × 480	256K	512K	1 MB	1 MB	2 MB
800 × 600	512K	512K	1 MB	2 MB	2 MB
1,024 × 768	1 MB	1 MB	2 MB	4 MB	4 MB
1,152 × 1,024	1 MB	2 MB	2 MB	4 MB	4 MB
1,280 × 1,024	1 MB	2 MB	4 MB	4 MB	6 MB
1,600 × 1,200	2 MB	2 MB	4 MB	6 MB	8 MB

Color depth is directly related to the number of bits used to compose one pixel and can be 4, 8, 16, or 24 bits per pixel. The larger the number of bits allocated to storing each piece of data, the more accurate the value can be; in like manner, the greater the number of bits allocated to store the value of pixel color, the greater the number of color shades you can use and color depth you can have.

To determine the number of colors that can be represented by these numbers of bits, use the number of bits as the power (exponent) of the number 2. For example, to calculate the number of colors represented by 4 bits per pixel, raise 2 to the 4^{th} power, which equals 16 colors. (Note that the largest 4-bit number is 1111, which equals 15 in decimal. If you include 0, then the number of values that can be stored in a 4-bit number is 16.) A color depth of 24 bits per pixel equals 2 to the 24^{th} power, or 16.7 million colors.

To determine the amount of RAM needed for one frame buffer, multiply the number of bits per pixel times the number of pixels on the screen, giving the total number of bits per

screen. Divide the number of bits by 8 to determine the number of bytes of RAM needed for the buffer.

For example, for a screen resolution of 1,024 × 768 and 256 colors, Table 9-8 shows that the amount of RAM required is 1 MB. The way that number is derived is illustrated below:

- The number of pixels for one frame buffer: 1,024 × 768 = 786,432 pixels
- For 256 colors, you need an 8-bit color depth, or 8 bits per pixel. (Remember that 1111 1111 in binary equals 255 in decimal, which, along with the value zero, provides 256 options.)
- Number of bits for one frame buffer: 786,432 pixels × 8 bits/pixel = 6,291,456 bits
- Number of bytes of memory needed: 6,291,456 bits/8 bits per byte = 786,432 bytes
- Since most video RAM comes in either 512K, 1 MB, 2 MB, or 4 MB increments, you must have 1 MB of video RAM to accommodate the frame buffer of 786,432 bytes.

In building a pixel on screen, each pixel uses three channels for color: red, green, and blue. However, when building 3-D graphics, a fourth channel is sometimes added called the alpha channel. The alpha channel controls the way the three colors are displayed and can add transparency or opacity to the image. The term for adding these effects is alpha blending, which can create the effect of shading or making one color partly visible behind another color, such as when you are looking through colored glass at a different color behind the glass. The alpha channel adds another 8 bits to the information kept for each pixel. When using 24-bit true color with an 8-bit alpha channel, 32 bits per pixel is needed, resulting in 32-bit graphics used by high-end video cards. The memory required for these cards is listed in the last column of Table 9-8.

Another factor that determines how much video memory is required is the bus width on the card. Just as with system boards, the RAM configuration on the card must conform to the bus width so that data can move from the bus to the card. A normal 1-MB memory chip on a video card has a bus width of 32 bits. In Figure 9-42, because each 1-MB video RAM chip is 32 bits wide, you can see why 2 MB of memory are needed if the video bus is 64 bits wide. In fact, this bit width of the video chip is the reason that a video card that has a 64-bit bus width and only 1 MB of installed memory is so slow. If your video card uses a 64-bit bus, be sure to install at least 2 MB of RAM.

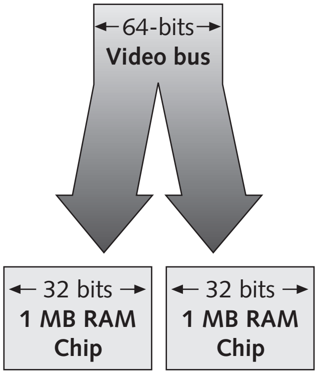


Figure 9-42 Video bus with 64-bit width addressing two 1-MB memory chips with 32-bit widths

In Figure 9-43, 4 MB of RAM are required to make the most efficient use of the 128-bit video bus width. Some manufacturers of video chip sets have developed a method to use a 128-bit bus with less than 4 MB of memory. For example, the Tseng Labs ET6000 chip set uses a special kind of video RAM called **Multibank DRAM (MDRAM)** that is able to use the full 128-bit bus path without requiring the full 4 MB of RAM.

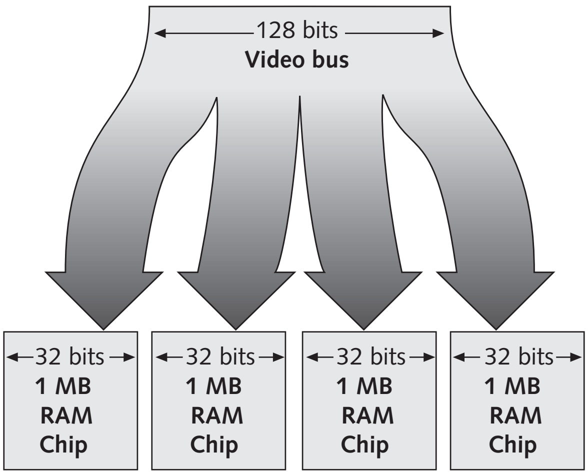


Figure 9-43 128-bit video bus addressing 4 MB of video memory

All these factors affect how much memory is required to build a single frame buffer. In Table 9-8, you can see that the most memory needed to build a single frame buffer is 8 MB. However, in addition to needing memory to hold each frame buffer, a graphics accelerator card might also need memory for other purposes. Software that builds 3-D graphics on screen often uses textures, and sometimes a graphics card holds these textures in memory to build future screens. Large amounts of video RAM keep the card from having to retrieve

these textures from the hard drive or system RAM multiple times. In addition, the graphics card might use double or triple buffering to improve performance in which the card holds not just the frame being built, but the next one or two frames. Because of texturing and triple buffering, a card might need as much as 32 MB of RAM. See the graphics card documentation for information about memory recommendations for maximum performance.

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Types of Video Memory

You have already been introduced to several different versions of video memory. Dual-ported memory, one type of which is sometimes called **video RAM** or **VRAM**, is designed so that video memory can be accessed by both the input and output processes at the same time. MDRAM memory chips are designed so that the full width of the video bus can be used with fewer memory chips than needed to provide the full bus width access to RAM. Three other types of memory chips designed to improve performance of video cards are: WRAM, SGRAM, and 3-D RAM.

SGRAM (synchronous graphics RAM) is similar to SDRAM, discussed in Chapter 4, but designed specifically for video card processing. SGRAM, like SDRAM, can synchronize itself with the CPU bus clock, which makes the memory faster. SGRAM also uses other methods to increase overall performance for graphics-intensive processing, but is not dual-ported memory. It is used on moderate to high-end cards where the very highest resolutions are not required.

WRAM (Window RAM) is a type of dual-ported RAM, but is faster and less expensive than VRAM. WRAM was named more for its ability to manage full-motion video than for its ability to speed up Microsoft Windows video processing. WRAM's increase in speed is primarily due to its own internal bus on the chip, which has a data path that is 256 bits wide. WRAM is used on high-end graphics cards with very high resolutions and true color.

Some video processing involves simulating 3-D graphics; **3-D RAM** was designed specifically to improve this performance. Much of the logic of 3-D processing is embedded on the chip itself. A graphics card chip set normally calculates which pixel of a 3-D graphic is to be displayed, depending on whether or not the pixel is behind other pixels and, therefore, out of sight in a 3-D graphic. After the pixel is drawn and a calculation is made as to whether or not the pixel is seen, if the pixel is not to be displayed, the chip set writes it back to memory to be used later. With 3-D RAM, the chip set simply passes the data to the 3-D RAM chip that draws the pixel and decides whether or not to display it without involving the chip set.

Chapter Summary

- Adding new devices to a computer requires installing hardware and software and resolving possible resource conflicts.
- Most hardware devices require similar resources from a computer, including an IRQ, DMA channel, I/O addresses, and some upper memory addresses to contain their device drivers.

- Use MSD under DOS and Device Manager under Windows 9x to determine what resources currently installed devices are using.
- 16-bit real mode device drivers are loaded from command lines in CONFIG.SYS and AUTOEXEC.BAT, and 32-bit protected mode drivers are automatically loaded by Windows 9x because of entries in the Registry.
- Most computers provide two serial ports and one parallel port to be used for a variety of devices. Newer system boards also provide one or two USB ports and an IEEE 1394 port.
- A null modem connection is used to connect two computers using their serial ports and a cable, but no modems.
- The UART chip controls serial ports.
- Because data bits in parallel might sometimes lose their relationship with the byte they represent, parallel cables should not exceed 15 feet in length.
- Three types of parallel ports are standard, EPP, and ECP. The ECP type uses a DMA channel.
- Older general-purpose I/O cards provided serial and parallel ports as well as IDE adapters because these were not included on a system board.
- The USB bus only uses one set of system resources for all USB devices connected to it.
- The IEEE 1394 bus provides either a 4-pin or 6-pin connector, uses only one set of system resources, and is hot-pluggable.
- A system board can have up to four PCI slots. IRQs are assigned to PCI slots during startup.
- If the system board and the OS both support PCI bus IRQ steering, IRQs can be reassigned by the OS after booting, in order to resolve a conflict.
- When selecting a SCSI host adapter, consider the bus slot the adapter will use, the device driver standard used by the host adapter, single-ended versus differential SCSI, SCAM compliance, and whether or not the host offers bus mastering.
- Some inexpensive SCSI host adapters are sold bundled with hardware devices that only support one or two SCSI devices.
- A keyboard can use a DIN, PS/2, or USB connector.
- Two types of monitors are CRT and LCD. CRT costs less, but LCD yields better quality and takes up less desktop space.
- A video card is rated by the bus that it uses and the amount of video RAM on the card. Both features affect the overall speed and performance of the card.

KEY TERMS

3-D RAM — Special video RAM designed to improve 3-D graphics simulation.

Bandwidth — the range of frequencies that a communication cable or channel can carry. In general use, the term refers to the volume of data that can travel on a bus or over a cable.

Break code — A code produced when a key on a computer keyboard is released. *See* Make code.

Bus mouse — A mouse that plugs into a bus adapter card and has a round, 9-pin mini-DIN connector.

Color depth — The number of possible colors used by a monitor. Determines the number of bits used to compose one pixel. One of two characteristics (the other is resolution) that determines the amount of data sent to the video card to build one screen.

Dot pitch — The distance between the dots that the electronic beam hits on a monitor screen.

Dual ported — When the video chip set (input) and the RAM DAC (output) can access video memory at the same time. A special kind of video RAM is required.

ECP (extended capabilities port) — A bi-directional parallel port mode that uses a DMA channel to speed up data flow.

EPP (enhanced parallel port) — A parallel port that allows data to flow in both directions (bi-directional port) and is faster than original parallel ports on PCs that only allowed communication in one direction.

Flat panel monitor — A desktop monitor that uses an LCD panel.

Graphics accelerator — A type of video card that has an on-board processor that can substantially increase speed and boost graphical and video performance.

Hot-pluggable — A characteristic of 1394 devices that let you plug in the device without rebooting your PC and remove the device without receiving an error message.

Interlace — A display in which the electronic beam of a monitor draws every other line with each pass, which lessens the overall effect of a lower refresh rate.

IEEE 1284 — A standard for parallel ports developed by the Institute for Electrical and Electronics Engineers and supported by many hardware manufacturers.

I/O card — A card that often contains serial, parallel, and game ports on the same adapter board, providing input/output interface with the CPU.

Isochronous data transfer — A method used by IEEE 1394 to transfer data continuously without breaks.

Make code — A code produced by pressing a key on a computer keyboard. *See* Break code.

Modem eliminator — A technique that allows two data terminal equipment (DTE) devices to communicate by means of a null modem cable in which the transmit and receive wires are cross-connected, and no modems are necessary.

Multibank DRAM (MDRAM) — A special kind of RAM used on video cards that is able to use a full 128-bit bus path without requiring the full 4MB of RAM.

Multiscan monitor — A monitor that can work within a range of frequencies, and thus can work with different standards and video cards. If offers a variety of refresh rates.

Non-interlace — A type of display in which the electronic beam of a monitor draws every line on the screen with each pass. See interlace.

Null modem cable — *See* Modem eliminator.

Parallel port — A female port on the computer that can transmit data in parallel, 8 bits at a time, and is usually used with a printer. The names for parallel ports are LPT1 and LPT2.

PCI bus IRQ steering — A feature that makes it possible for PCI devices to share an IRQ. System BIOS and the OS must both support this feature.

Pixel — Small spots on a fine horizontal scan line that are illuminated to create an image on the monitor.

PS/2 compatible mouse — A mouse that uses a round mouse port (called a mini-DIN or PS/2 connector) coming directly off the system board.

Resolution — The number of spots called pixels on a monitor screen that are addressable by software (example: 1024 2 768 pixels).

Serial mouse — A mouse that uses a serial port and has a female 9-pin DB-9 connector.

Serial ports — Male ports on the computer used for transmitting data serially, one bit at a time. They are commonly used for modems and mice, and in DOS are called COM1 or COM2.

SGRAM (synchronous graphics RAM) — Memory designed especially for video card processing that can synchronize itself with the CPU bus clock.

System-board mouse — A mouse that plugs into a round mouse port on the system board. Sometimes called a PS/2 mouse.

UART (universal asynchronous receiver/transmitter) chip — A chip that controls serial ports. It sets protocol and converts parallel data bits received from the system bus into serial bits.

Video RAM or VRAM — RAM on video cards that holds the data that is being passed from the computer to the monitor and can be accessed by two devices simultaneously. Higher resolutions often require more video memory.

Window RAM (WRAM) — Dual-ported video RAM that is faster and less expensive than VRAM. It has its own internal bus on the chip, with a data path that is 256 bits wide.

9

REVIEW QUESTIONS

1. Name four system resources that a device might need and that offer the potential for a conflict with another device.
2. Why would an external modem cost more than an internal modem?
3. In DOS, what command loads a device driver? Where is the command located?
4. Name three possible ways a scanner might interface with a system board.
5. By definition, what system resources does COM1 use? COM2? COM3? COM4?
6. To what does RS-232 refer?

7. How many pins are on a typical serial mouse port?
8. What is a null modem cable, and what is it often used for?
9. What chip controls the speed of serial ports? What DOS utility program can you use to determine what version of this chip you have installed?
10. Why might you choose to use ECP mode for your parallel port rather than EPP mode?
11. When might you need to disable ECP mode for a parallel port?
12. How are system resources assigned to ports on a typical, general-purpose I/O card?
13. In order for your system to support a USB device, what three resources must you have?
14. What OS supports USB?
15. What is the maximum number of PCI slots that a system board might have?
16. What utility tool can help resolve system resource conflicts in DOS? In Windows 9x?
17. When installing a device, why would you prefer to use a PCI expansion slot rather than an ISA expansion slot?
18. Explain what PCI bus IRQ steering does. When might you disable it?
19. If PCI is attempting to use an IRQ that is used by a legacy ISA device, how can you force PCI to not use the IRQ?
20. If the port on a SCSI host adapter has only 25 pins, what does this tell you about the adapter?
21. How much video RAM is required to produce a resolution of 800 $\times$ 600 with 65,000 colors?
22. Give three examples of monitor screen sizes. How are monitor screen sizes measured?
23. Which provides better quality, an interlaced monitor or a noninterlaced monitor? Why?
24. What type of monitor can offer a variety of refresh rates?
25. What size frame buffer is needed on a video card to hold the data for 1,280 $\times$ 1,024 screen resolution and 65,000 colors?
26. What makes a device an ergonomic device?
27. Describe the size and pins on a DIN connector and a PS/2 connector for a keyboard.
28. What three colors are used to build all colors on a color monitor screen?
29. Which gives better image quality, a .25-mm dot pitch monitor or a .28-mm dot pitch monitor? Why?
30. If a mouse begins to be difficult to operate, what simple thing can you do to help?

PROJECTS

CAUTION

Unless you follow proper procedures, working inside your computer can cause serious damage—to both you and your computer. To ensure safety in your work setting, follow every precaution listed in the *Read This Before You Begin* section following this book's Introduction.

Hands-on Project

Supporting a Mouse in DOS

Prepare a bootable DOS floppy disk that provides access to a mouse. Test that you can use the mouse by booting from the disk and using the mouse when executing MSD. What driver file must be on the disk in order for it to support a mouse?

Hands-on Project

Protected-Mode and Real-Mode Drivers

Windows 9x provides 32-bit protected-mode drivers for a mouse. Using either Windows 98 or Windows 95, print the screen showing the drivers currently used for your mouse. Now substitute a 16-bit real-mode driver for your mouse. How does the icon for the mouse change in Device Manager? Print the screen showing the current driver in use. *Hint*: Real-mode drivers are loaded from CONFIG.SYS.

Hands-on Project

Research Hardware and Software on Your Computer

Know the computers for which you are responsible. Gather the documentation for your computer and/or use the Nuts & Bolts software on the accompanying CD-ROM and fill in the following chart. Copy the chart and put it in the notebook that is kept for this computer. To use Nuts & Bolts to gather information about your computer, click **Start**, **Programs**, **Nuts & Bolts**, and **Discover Pro**.

Computer Fact Sheet

Location of computer: ____________________

Owner: ____________________

Date purchased: ____________________

Warranty expires: ____________________

Size and speed of CPU: ____________________

RAM present: ____________________

Type of monitor: ____________________

Type of video card: ____________________

Hard drive type: ____________________

Hard drive size: ____________________

Disk drive A size: ____________________

Disk drive B size: ____________________

Software Installed:

Name	Version	Installed by	Date
1.			
2.			
3.			
4.			
5.			

Other Devices:

Name of Device	IRQ	I/O Address	DMA Channel	Device Driver Filename
1. Serial port 1				
2. Serial port 2				
3. Parallel port				
4. Mouse				
5. Modem				
6. CD-ROM drive				
7.				
8.				

Install a Device

Install a device on a computer. If you are working in a classroom environment, you can simulate an installation by moving a device from one computer to another.

Research a Computer Ad

Pick a current magazine ad for a complete, working computer system including computer, monitor, keyboard, and software, together with extra devices such as a mouse or printer. Write a four- to eight-page report describing and explaining the details in this ad. This exercise will give you a good opportunity to learn about the latest offerings on the market as well as current pricing.

Compare Two Computer Ads

Find two computer ads for computer systems containing the same processor. Compare the two ads. Include in your comparison the different features offered and the weaknesses and strengths of each system.

Using Nuts & Bolts to Examine Multimedia Devices

1. Using Nuts & Bolts Discover Pro, print a full description of your PC's sound, video, and printer functions. Include in the printout the amount of RAM that is stored on the video card.
2. What are the current resolution and number of colors of your monitor? Calculate the size of the frame buffer required for these settings. Compare your results to the calculation made by Nuts & Bolts under System in Discover Pro.

Search the Internet for an Older Video Driver

You have a 486DX computer with a VESA local bus video card by Avance Logic, Inc. You upgrade your DOS 6.22 and Windows 3.1 operating systems to Windows 95. When you install the video, you discover that Windows 95 does not support Avance Logic video drivers. You temporarily substitute a standard super VGA driver so you can complete the installation, but you notice that the video and color are not as clear as you think they should be. How do you resolve the problem? Follow these steps to a solution.

1. On the Internet, find the web site for Avance Logic, Inc. Here's where some educated guessing can be effective. Try *www.avance.com*.
2. Look for drivers for Windows 95. Your video card is labeled Avance Logic 2228. After a little searching, you arrive at the screen shown in Figure 9-44.
3. Download and explode the file labeled ALG2228.
4. Print the Readme.txt file that lists the instructions to use to install the new device driver in Windows 95. If you follow the instructions, don't apply the driver unless you really do have this particular video card.

Plan the Design of a 9-Pin Null Modem Cable

Draw a chart similar to Table 9-4 showing the pinouts (functions of each pin) for a 9-pin null modem cable.

Parallel Port Modes

Examine CMOS setup on your PC and answer the following questions about your parallel port:

1. Is there a parallel port coming directly off the system board?
2. What modes are available for the parallel port?
3. What is the currently selected mode?
4. If the parallel port supports ECP, what DMA channels can be selected for this mode?
5. Disable the parallel port using CMOS setup. Reboot the PC and attempt to use the port by executing a print command. What is the error message that you get?

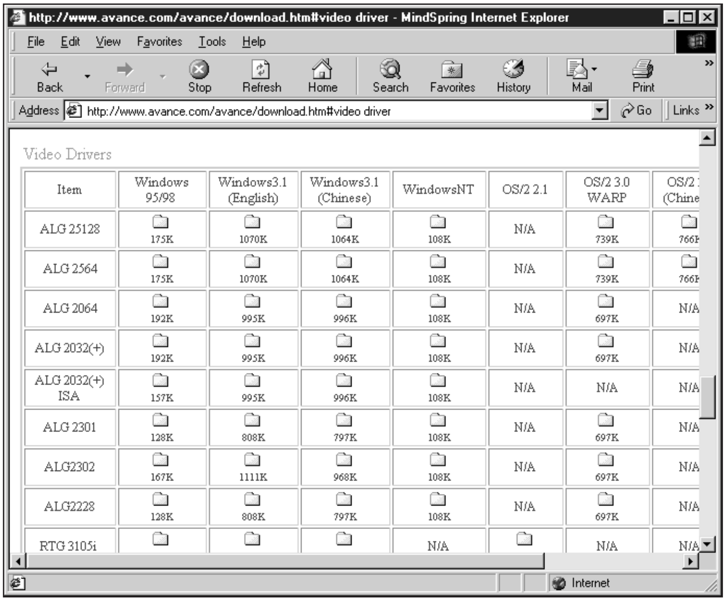

Figure 9-44 Video drivers for Windows 9x

Hands-on Project

Troubleshooting Skills

Produce a troubleshooting situation by assigning the same IRQ to two devices. In some computer systems that use mostly PCI and Plug and Play devices, creating a conflict can be a real challenge. Older systems that use several legacy devices will prove to be much less of a challenge. Attempt to use the two devices at the same time and note what happens when you do that. Possible devices to use are a serial mouse, a modem, or a parallel port connected to a printer. Answer these questions:

1. What two devices did you use to create a conflict?
2. How did you create the conflict?
3. When you attempted to use both devices, what happened?

Hands-on Project

Working with a Monitor

1. Using Windows 9x, list the steps to change the monitor resolution. If you make a mistake when changing the monitor resolution, Windows 9x is much better about not allowing you to lock up your video than is Windows 3.x.
   - Double-click the **Display** icon in the Windows **Control Panel** and practice changing the background, screen saver, and appearance. If you are not using your own computer, make sure to restore each setting after making changes.
   - Pretend you have made a mistake and selected a combination of foreground and background colors that makes it impossible to read the screen. Solve the problem by booting Windows 9x into Safe Mode. Correct the problem and then reboot.

2. Windows 9x offers many new 32-bit video drivers for most video cards. When Windows 9x is first installed, it selects the driver for you based on the video card it detects. To see a list of available video drivers, follow these procedures:
   - Right-click the **desktop**, and click **Properties** on the shortcut menu to open the Display Properties dialog box.
   - Click the **Settings** tab. The choices available depend on the resources you have on your computer.
   - Change the resolution by using the sliding bar under **Display area**. The changes are immediate; you don't have to exit and reenter Windows, as you did in Windows 3.x. Make a change and then make the change permanent. You can go back and adjust it later if you like.
3. Work with a partner who is using a different computer. Unplug the monitor in the computer lab or classroom, loosen or disconnect the computer monitor cable, and/or turn the contrast and brightness all the way down, while your partner does something similar to his/her PC. Trade PCs and troubleshoot the problems.
4. Turn the PC off, remove the case, and loosen the video card. Turn the PC back on and write down the problem as a user would describe it. Turn off the PC, reseat the card, and verify that all is working.
5. Insert a defective monitor adapter card provided by your instructor into a system. Describe the problem in writing, as a user would describe it.